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COMMITTEE ON ACCELERATION OF THE REGULAR ENGINEERING PROGRAMS

REPORT TO ADVISORY COMMITTEE, MARCH 2, 1941

The Advisory Committee on Engineering Defense Training of the United States Office of Education requested the Society for the Promotion of Engineering Education on February 8, 1941, to consider the feasibility and advisability of accelerating the regular engineering programs of the engineering colleges. President Prentice immediately appointed a committee. A questionnaire was prepared and sent to 135 engineering colleges. 119 replies were received. The Committee met in Pittsburgh on March 1–2 and analyzed these returns, and begs to submit its report.

The Committee was greatly impressed by the unanimous desire of the engineering colleges to coöperate in every possible way to further the defense program and by the careful and thoughtful manner in which the answers to the questionnaire had been prepared.

The Defense Program, in its present stage, is primarily a problem of mass production. Such production requires engineers for design, construction, supervision, maintenance, the teaching of operators, and research work that will produce defense equipment of new design fast enough to lead the rapid obsolescence inherent in the competition between the defensive and the offensive phases of war activities.

The entirely new demands of our greatly expanded Army, Navy and industry have created an unprecedented need for engineers. The resulting overdraft of engineers is several times the supply available. The engineering college is the sole source of supply to meet this deficiency. This fact raises the immediate question whether the engineering colleges can do anything to relieve this bottleneck in the defense program.

A large number of short intensive courses which have already been put into effect by a great majority of the engineering colleges of the country coöperating with the U. S. Office of Education will supply men to fill many of the needs. These courses cannot adequately meet the demand for highly trained engineers.

In view of the acute need, especially in the coming year when production is expected to reach its peak, the Committee feels that some plan should be inaugurated for accelerating the graduation of engineering students, particularly the class of 1942.

The Committee wishes to emphasize that the problem of an accelerated program is closely linked with that of the induction of engineering students, teaching staff, and recent engineering graduates into military service. Such a program will lose a large part of its possible effectiveness unless staffs are maintained, students of engineering are granted draft deferment until graduation, and engineering graduates are permitted to engage in work for which they are specially trained.

After careful consideration and full discussion of the information presented by 119 engineering colleges, through returns to the Society for the Promotion of Engineering Education, the Committee concludes that:

1. Any accelerated program adopted should not reduce or materially change the content of the engineering curricula.

2. Most engineering colleges can graduate the engineering class of 1942 early in that year by utilizing the summer vacation of 1941 for regular curriculum instruction. This action will advance the date of graduation several months for approximately 12,000 young engineers and make them available at about the time of the peak demand of the defense program. The Committee feels that coöperative courses should not be accelerated since they already operate on a twelve-month basis and the students spend half of their time in industry. It is apparent that these courses could not be shortened without withdrawing a large number of students from essential industrial employment.

3. Institutions would find it difficult to operate both accelerated and normal programs simultaneously.

4. The added cost of an accelerated program should be borne by the Federal government, and the allotments to institutions engaged therein should cover both the actual additional costs imposed by summer sessions and the losses of income caused by early graduation resulting from the accelerated program. It is estimated that these costs may be as much as $2.00 per clock hour of instruction per student, or even more in some exceptional cases. If all the engineering colleges should adopt the accelerated program for the final year, except for coöperative courses, the total added cost of such a program for the summer of 1941 would amount to approximately $5,000,000.00. This estimate of cost is based on the assumption that institutions adopting the accelerated plan for the class of 1942 will make this plan compulsory for all students in that class. If it is necessary to offer both the accelerated and the normal curricula in parallel, the cost will be greatly increased, perhaps as much as fifty per cent.

5. If the accelerated plan is to be put into effect for the coming summer, it will be necessary to come to a decision to that effect and to announce the program promptly in order that students and staff may have ample warning of the cancelling of the summer vacation. Early announcement is especially important if the accelerated program is to be the only program offered.

6. These accelerated courses should be operated as a part of the present Engineering Defense Training program conducted under the auspices of the U. S. Office of Education.

7. The government should make provision for loans, not to exceed $50.00 per student per month, to cover subsistence for those students requiring financial aid. The need of this aid arises from the fact that the students enrolled in the accelerated programs will be deprived of their opportunities for customary summer employment, as was emphasized in the returns from the engineering colleges surveyed.

It must be recognized that R.O.T.C. students enrolled in the accelerated programs must defer summer military training until after graduation.

The acceleration of the entire four-year program of engineering education was also carefully considered and the conclusions are that:

1. The application of such a program for the summer of 1941 to the class of 1943 (present sophomores) would be generally inadvisable for the following reasons:

(*a*) In general, sophomores are not sufficiently mature to endure the strain of carrying the work normally covered in three academic years in a continuous program without serious impairment of the student's ability at the time of graduation. Adoption of such a program might actually result in a net loss to industry.

(*b*) Having two classes in session during the summer would require serious curtailment of the Engineering Defense Training program with the desired emphasis on full-time pre-employment courses during that period.

(*c*) Many engineering curricula require shop, laboratory and field courses during a portion of the summer following the sophomore year which would have to be omitted if the regular class programs were continued through that period.

(*d*) Sophomores not required to attend summer sessions can secure work in industry, thereby gaining valuable experience and, at the same time, contributing to the defense production.

2. It would be unwise to start the class of 1944 (present freshmen) and the class of 1945 (now seniors in high school) on a continuous three-year course of study. The transition from high school to college engineering courses is very difficult and to subject freshmen to an accelerated program immediately after graduation from high school would create additional difficulty.

Finally, the Committee wishes to call attention to the penalties that will be imposed upon students and teaching staff by even the one-year accelerated program proposed in this report. These may be summarized briefly as follows:

1. Continuous study for approximately 18 months without change of occupation for students even as far advanced as seniors may lower the effectiveness of the educational process.

2. The added burden of senior class instruction in the summer months limits the availability of teaching staffs for Engineering Defense Training courses during this strategic period.

3. Valuable research, including many defense and industrial activities, as well as consulting practice for government and industry, usually engaged in by faculty members will be materially interfered with by the accelerated program.

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LETTER FROM PRESIDENT D. B. PRENTICE TO THE COMMITTEE ON ACCELERATION OF THE REGULAR ENGINEERING PROGRAMS

March 12, 1941

At Dean Potter's invitation I attended a meeting of the Advisory Committee in Washington last Saturday and presented our report. The report was accepted by the Advisory Committee with sincere thanks for the work which had been done. The Advisory Committee voted to make the same recommendation to the United States Office of Education as our report contained.

There was a long discussion as to the advisability of summer courses for the present freshmen and sophomores but no action was taken except to request Dean Potter as chairman to get in touch with the proper officials of the Army, Navy and OPM, to learn, if possible, the expected needs for engineering graduates. Dean Potter telephoned me last night that he spent Sunday and Monday making this investigation and did not secure any information which would, in his opinion, justify such a program.

Because of the expense connected with operating the engineering colleges during the summer for the present juniors, it is unlikely that the Office of Education will recommend to Congress an appropriation for this purpose. As we calculated it, possibly the cost per man month of earlier service in industry for the present juniors would be from $125.00 to $150.00.

It is felt that an extension of the present EDT program by the engineering colleges during the summer months will be more effective than a speed-up for the regular classes.

I want to thank you again for your willingness to meet in Pittsburgh and for the good work you did in preparing the report.

FAST METHOD FOR FINDING AREAS OR MEAN ORDINATES OF CURVES

By A. D. MOORE

Professor of Electrical Engineering, University of Michigan

Over ten years ago, the writer devised a new method for finding the mean ordinate of a curve. The method is so simple, so fast, so free (relatively) from possibility of error, and so accurate, that in numerous instances it should displace the use of the planimeter, Simpson's Rule, counting of squares, and other methods.

In order to explain the method, it is necessary herein to show certain arguments, procedures, and constructions. The reader may thus get a first impression that the method involves a good deal of graphical work, and that the method cannot be as speedy as is claimed. However, it will be shown at the end of this paper, that in a great many ordinary cases the method may be applied with extreme simplicity.

As in some other methods, this one involves dividing the area under a curve into vertical strips. By dealing with a sufficiently narrow strip, it is always possible to segregate an arc of a smooth curve, such that the arc is essentially an arc of a parabola. Therefore, we begin by dealing with the properties of a parabolic curve.

Figure 1*a* shows a symmetrical parabola. It has long been known that the mean ordinate *PO* lies along the middle vertical, the point *O* being one-third the distance from arc to the chord (or base) *AB*. Next, divide this area into an infinite number of vertical strips. Next, slip these strips vertically downward into Fig. 1*b*, until they rest on the chord *CD*. The formerly symmetrical parabola has now become a skewed parabola. The area has remained unchanged, and it is now equal to *PO* times *AB*. Point *O* is still one-third of the distance from arc to chord, *taken along the middle vertical*. *MP* times *AB* is obviously the area of the trapezoid. Therefore, *MO* times *AB* is the area under the curve, accurately; and *MO* is the curve's mean ordinate.

In Fig. 2, the curve *CD* has the base *AB*. The entire curve might be arbitrarily called a skewed parabola, and its mean ordinate *MO* found by locating *O* on the middle vertical at the one-third point from arc to chord *CD*. In fact, with a curve having a single smooth sweep such as this, to handle it "in one bite" will

bring in an answer with very small error, with amazing frequency, in spite of the apparent roughness of the assumption.

However, assume that we need the greater accuracy obtainable by dividing the area into two vertical strips of *equal width*. On the middle verticals in each strip, locate the two mean ordinates by the one-third rule. Join the tops of the mean ordinates, thereby finding point *O* at the intersection. *MO* is obviously the mean ordinate for the entire area, since the strip widths are equal; and *MO* times *AB* is the area under the whole curve.

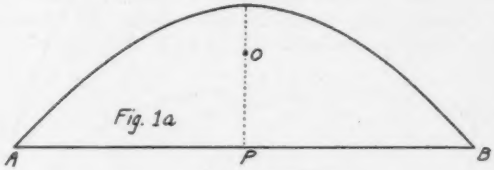

Fig. 1a

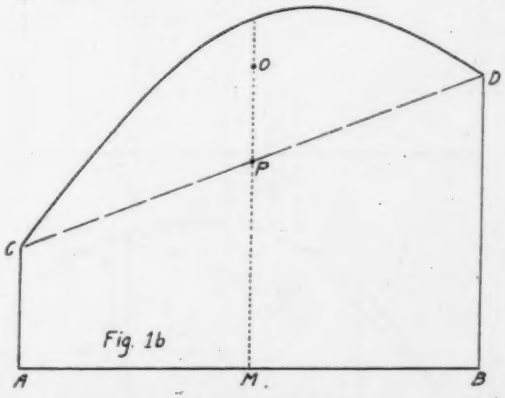

Fig. 1b

Suppose next, that in the case just treated, we had doubts about the accuracy obtained by taking the curve "in two bites." Instead, we could have taken four, and such a treatment is shown in Fig. 3. The area is divided into four strips of *equal width*. The right-hand pair and the left-hand pair are combined, as in Fig. 2. The tops of the mean ordinates of the pairs are joined, thus giving the intersection *O*. *MO* is the mean ordinate for the whole curve, and *MO* times *AB* is the area under the whole curve.

Before taking the steps that will generalize the method and free it from the necessity of taking strips of equal width, let us pause to consider accuracy. Suppose the one-third points are estimated by eye, and that some error therefore is present. Re-

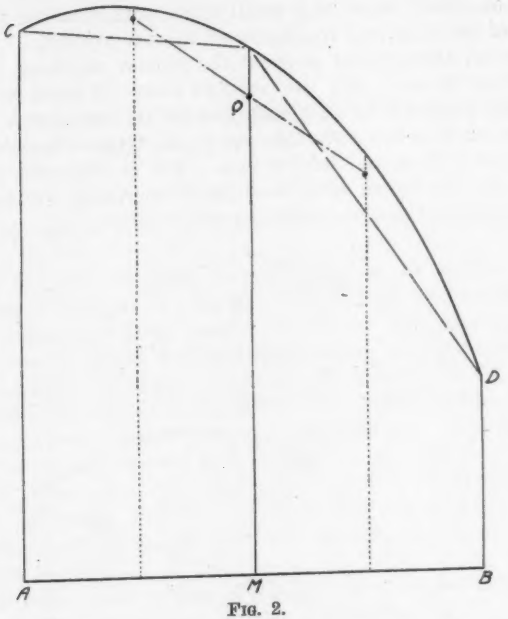

FIG. 2.

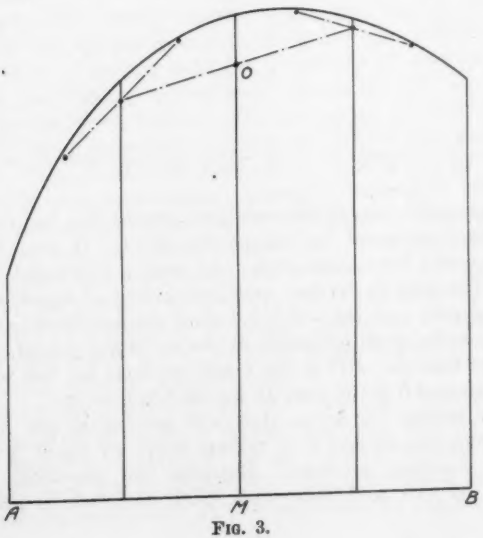

FIG. 3.

member also that the arcs of curves are only approximately parabolic. What then? In such a case as that of Fig. 3, the little areas between arcs and chords are the only areas affected by error, and they amount, on the average, only to perhaps 3 per cent of the total area involved. It follows that with any reasonably good estimate of point locations, and with smooth curves, the new method will typically yield results with less than 1 per cent error. The experience of the writer and of hundreds of his students leaves no room for doubt about this statement.

When we seek still greater accuracy, other factors must be mentioned. Among the great mass of curves that are worked with in numerous ways, only a small fraction are ordinarily plotted to

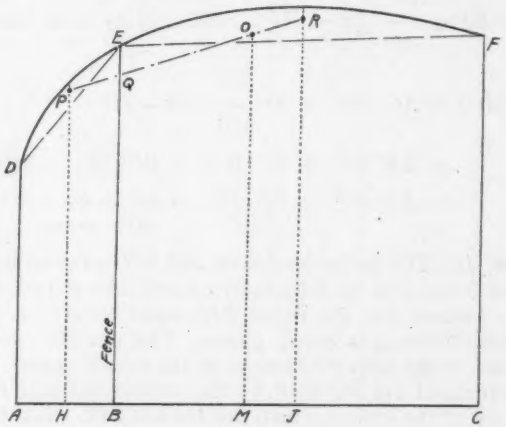

FIG. 4.

better than one-half of 1 per cent. The graph paper that is accurate within the same limits is equally rare. However, if plotting methods are highly accurate, if the paper is highly accurate, if lines and points are located with skill and care, and if the arcs selected are properly chosen, errors of less than one-half of 1 per cent are easily obtainable.

The generalized method in which strips need not be equally wide, is portrayed in Fig. 4. In a given case, it may appear that if the curve *DF* is treated in terms of arc *DE* and arc *EF*, each arc will in itself be closely parabolic. To treat in this matter calls for the narrow strip based on *AB* and the wide strip based on *BC*. Find the mean ordinate of each strip by applying the one-third rule along the middle verticals. Join the tops of the two mean ordi-

nates. BE is the "fence" between the two strips. P is at the distance PQ from the fence. Lay off this distance from R, such that RO equals PQ. Drop a vertical line through O. As will be proved, MO is the mean ordinate for the entire curve. Moreover, M automatically falls at the center of AC.

That MO is the mean ordinate will now be proved. It is easily seen that

$$MO = HP + \frac{HM}{HJ}(JR - HP).$$

But since, by construction, $BC = 2(HM)$ and $AC = 2(HJ)$

$$MO = HP + \frac{BC}{AC}(JR - HP).$$ Multiply by total base AC,

$$\begin{aligned} AC(MO) &= AC(HP) + AC\frac{BC}{AC}(JR - HP) \\ &= AB(HP) + BC(HP) + BC(JR) - BC(HP) \\ &= AB(HP) + BC(JR), \text{ which is the sum of the two strip areas.} \end{aligned}$$

Therefore, $AC(MO)$ is the total area, and MO is the mean ordinate.

Figure 5 can now be used to bring out several features of the method. Assume that the curve EH, based on AD, is drawn on ordinary 10-to-the-inch graph paper. The arc FG conveniently covers four of the inch-wide strips of the graph paper. Find the mean ordinate of arc FG at P by the method outlined for Fig. 3. P is the top of the mean ordinate for the arc FG. Now take in the arc GH by the method as of Fig. 4; thus the ordinate under Q becomes the mean ordinate for arc FH. Next take in arc EF by the same procedure, finally securing MO, mean ordinate for the entire curve.

As each side-piece is added in, the mean ordinate automatically falls where needed: in the middle of the total base taken in so far.

Figure 6 can be used to bring out some more of the general qualities of the method, some of which may prove confusing or even be overlooked, especially by students not overly familiar with graphics. The curve in Fig. 6 has a point of inflexion. By using such strips as will put a "fence" at the point of inflexion, arcs on either side of the fence will often be closely parabolic. In the lefthand strip, the curve arc is "inverted," compared with arcs heretofore shown. The method still applies: locate P on the middle vertical, one-third of the way from arc to chord. Proceed to get MO as in Fig. 4.

The other feature shown here is that the method is independent of the position of the axis: the axis may cut the curve, or be above or below the curve.

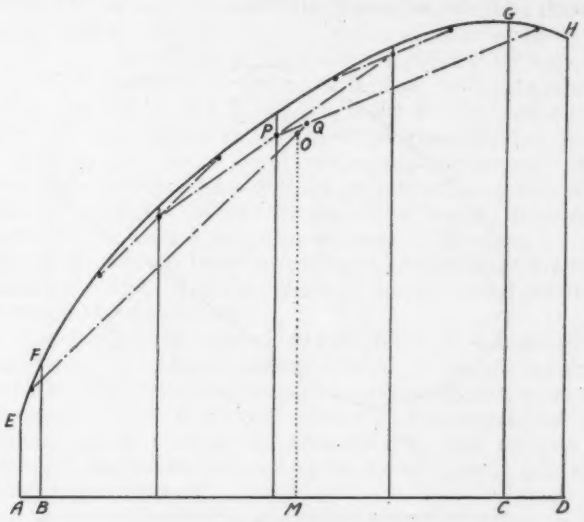

FIG. 5.

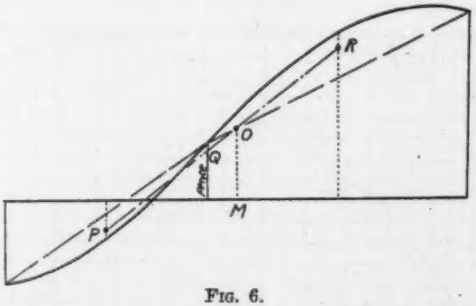

FIG. 6.

In Fig. 7, assume that all that is needed is to find the area of the closed curve *CD'ED*, and that originally, the axis *AB* was not even present. Put in any such axis as *AB*, and cut the total curve into the upper arc *CD'E* and the lower arc *CDE*, by means of tangent verticals *AC* and *BE*. Use such strips as are necessary (not shown in Fig. 7) to determine the two mean ordinates, *MO* for the

lower arc, MO' for the upper arc. Obviously, the enclosed area is

$$AB(MO') - AB(MO), \text{ or simply } AB(OO').$$

Obviously, AB can be located anywhere.

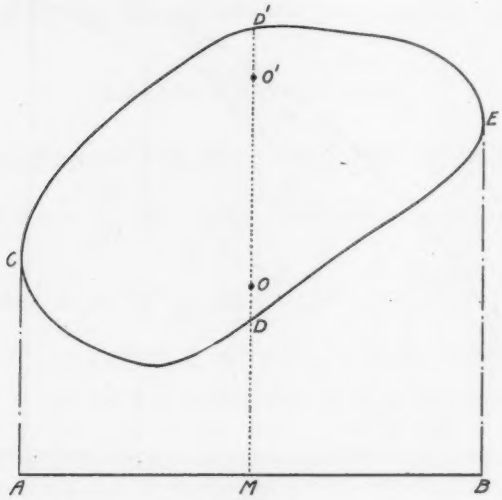

FIG. 7.

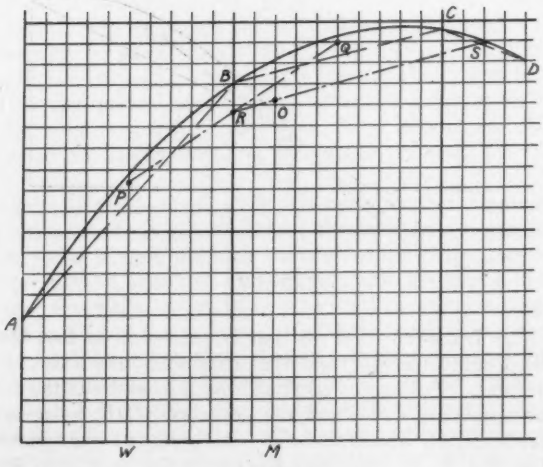

FIG. 8.

The simplicity and speed of the method, as applied to numerous ordinary situations, is illustrated in Fig. 8. Here, the curve *ABCD* is plotted on ordinary 10-to-the-unit graph paper. In this figure, the chord *AB* has been *drawn*. But in practice, it is not drawn at all: simply place a straight-edge to *A* and *B*, observe the middle vertical at *W* (a graph paper line), dot the point *P* by estimation of the one-third distance. Get point *Q* likewise. Shift the straight-edge to go through *P* and *Q*, dot the point *R*. By making only three dots, we have located *R*, the top of the mean ordinate for arc *ABC*. The arc *CD* "hangs over," and covers four spaces. Dot *S* by the methods just outlined. Put the straight-edge through *R* and *S*, count off two spaces (since *CD* covers four spaces) from *R*, locate *O* and dot it. *MO* is the mean ordinate of the curve.

As to speed: *MO* was found by placing a straight-edge five times, and making five dots. The time spent on this particular job would be between 40 and 60 seconds.

As to certainty: the method avoids errors of estimating and counting, in the counting-of-squares method; it avoids the errors sooner or later made in reading numerous ordinates involved in such methods as Simpson's Rule—also the arithmetic errors that may occur in numerically treating the ordinates after they are read off; and it puts the planimeter quite out of the picture, except for highly specialized, repetitive work.

The writer published "The Mean Ordinate of a Curve" (a condensed description of the method) in *The Michigan Engineer*, June, 1932. The local character of the circulation of that journal is such that the method is not yet widely known.

WHAT THE AIRCRAFT INDUSTRY EXPECTS OF THE ENGINEERING COLLEGE *

By C. T. REID

Director of Education, Douglas Aircraft Company, Inc.

We of the national defense industries, especially in aircraft, lately have been flooded with inquiries from schools, colleges and governmental departments concerning the extent of our needs for accelerated output of aeronautical engineers and about the curricula they should study. Various institutions have taken definite steps toward offering studies to meet the needs and have submitted their schedule outlines to us for comment.

Massachusetts Institute of Technology offers a plan to help ameliorate the situation by ten weeks' study of fundamentals of airplane design for men having training or experience in other branches of engineering.

Princeton University plans to do something about the shortage of practical draftsmen by taking time from broader subjects to permit more concentration on technical studies and shift the emphasis entirely to production.

The Aeronautical Chamber of Commerce of America announces a government sponsored plan to provide quickly an adequate supply of trained aeronautical engineers to meet the demands of the national emergency through post graduate courses of six months duration.

The United States Office of Education, we are told, is planning to meet the need created by shortage of stress analysts, airplane power plant designers and other engineering specialists through intensive courses lasting twelve weeks at certain selected institutions. The foundation of this plan forms the subject matter of the first two articles in the October issue of THE JOURNAL OF ENGINEERING EDUCATION.

All these people and others have asked us how many men we need to have trained, and all have invited our comments and suggestions relative to the plan and curriculum. It is evident from conversations and perusal of outlines submitted that the training they have in mind would run largely to advanced stress analysis and aerodynamical design. Our immediate reaction is that we must

* Presented at the 9th Annual Meeting, Pacific Southwest Section, S. P. E. E., held at the University of Southern California, December 27–28, 1940.

emphatically state that we *scarcely have any need at all for acceleration of this type of training.*

In proof of this statement, we invite attention to the survey of occupational opportunities in our engineering division which follows. All types of work done by men (stenography, etc., as handled by women, not counted) are combined into seven main categories, and the number and percentage of employees engaged in each is shown. It will be immediately noted that those doing stress analysis and aerodynamical work represent only eight per cent of the total.

AIRCRAFT ENGINEERING OCCUPATIONAL OPPORTUNITY STUDY
DOUGLAS AIRCRAFT COMPANY, INC.
October 1, 1940

Item		No. of Men	Rough Equiv. Percentage
I	Preliminary Design and Development	27	2
II	Aerodynamics	22	2
III	Stress Analysis and Structural Design	65	6
IV	Weight Analysis and Control	40	3
V	Production Design, Drafting and Checking	453	40
VI	Tracing, Blueprint and Record Work	313	27
VII	Administration, Supervision and Liaison	235	20
	TOTAL	1155	100

In the following will be found a detailed job analysis for each of these items, fully explaining its nature, identifying the source of man supply, etc.

ITEM I

Preliminary Design and Development

Twenty-Seven Men—2%

Duties:

Make three-views and pictorial drawings.
Make inboard profile to establish equipment locations.
Make master diagram to establish basic design of structure.
Rough out design of major structural members and fittings.

Qualifications Required:

All-around knowledge of airplane design and construction.
Thorough familiarity with latest manufacturing methods and local facilities.
Thorough familiarity with employer's own predecessor models.
Good acquaintanceship with competitive models.
Good understanding of engineering economics.

Thorough understanding of employer's business policies.
Natural drafting ability, versatility and ingenuity.

Training:

Graduation in upper fraction of class from one of highest ranking aeronautical schools (post graduate college work) or seven to ten years recent engineering employment with Army and Navy contractors accompanied by study on the side.

Experience:

At least two years of variety assignments in engineering employment with Army and Navy contractors.

Difficulty of Getting Men—Usual Deficiencies:

Not a great many of the graduates described exist. A large per cent of these want to go immediately into aerodynamical or stress analysis work rather than accumulate experience on the board. Of the men trained in the ranks, not a very large number have had the amount of experience here specified.

Solution:

Pick promising young men in industry and accelerate development through planning of variety work and facilitating studies on the side (shop training course helps greatly).
Not a school problem!

Opportunities for Advancement:

Eligible for promotion to group leader, project engineer, etc.

ITEM II

Aerodynamics

Twenty-Two Men—2%

Duties:

Settle aerodynamical considerations in layout of new designs and revisions of old ones; performance, stability, maneuverability, etc.
Provide contract guarantees of aerodynamical characteristics.
Design wind tunnel model and employ it in test program.
Determine loadings and load distribution for stress analysis.
Conduct full scale flight test engineering of finished airplane.

Qualifications Required:

Thorough facility with mathematics through differential equations and complex variables.
Thorough facility with physics of fluid flow and its application to airplane design.
Good general knowledge of existing types of airplanes, their characteristics and performance.
Mechanical design ability.
Strong aptitude for mathematical work.
Ability at engineering report writing.

Training:

Highest level of aerodynamical study (five to eight years of college work in highest ranking aeronautical institutions).

Experience:

No fixed amount of experience required. Trained men are immediately useful. The more previous experience the better, however, for seasoning and development of judgment.

Difficulty of Getting Men—Usual Deficiencies:

Only a few complete the post graduate work each year, and not all of these are useful. People with less training than specified fall down badly on fundamental theory.

Solution:

Graduate more men and more suitable ones.

Persuade more math and physics majors, who are interested in industry, to take the necessary post graduate work.

Opportunities for Advancement:

Eligible for promotion to group leader, project engineer, etc., provided shop contact experience is gained through association with mechanical work on wind tunnel models, test set-ups, etc.

Item III

Stress Analysis and Structural Design

Sixty-Five Men—6%

Duties:

Take major aerodynamical loads and apply to the structure conceived by preliminary design men for determination of sizes of members.

Report detail analyses to government for approval.

Furnish to design draftsmen information on minor loads for use in detail design.

Strength Check Drawings of all vital parts of the airplane.

Conduct proof load tests of completed units and airplanes.

Qualifications:

Thorough knowledge of technical mechanics and strength of materials as applied to modern aircraft design.

Thorough understanding of government standards and rules of procedure for airplane stress analysis.

Strong aptitude for mathematical work.

Ability at engineering report writing.

Training:

Graduation from at least a four-year course in one of the better schools of aeronautics, or private study on the side to the equivalent level of development.

Experience:

No fixed amount required. Trained men are of immediate use, but experience greatly enhances value.

Difficulty of Getting Men—Usual Deficiencies:

Most so-called aeronautical engineering courses given inadequate training.

Solution:

Improve practical value of courses.

Facilitate to promising young employees extension study along these lines.

Opportunity for Advancement:

Eligible for promotion to production design drafting or preliminary design assignment.

ITEM IV

Weight Analysis and Control

Forty Men—3%

Duties:

Calculate weights, moments and centers of gravity of airplane components and complete airplane.

Determine effects of variables in loading and advise best distribution of pay load under various operating conditions.

Supervise actual weighing of parts in shop as construction progresses and check actual weights against calculated values to guard against design discrepancies.

Qualifications Required:

Fundamental engineering knowledge, preferably with some study of aeronautics included.

Facility with slide rule and calculating machines.

Ability at engineering report writing.

Training:

Graduation from four-year aeronautical engineering school or mechanical engineering school with senior options in aeronautical engineering.

Experience:

No previous experience required for a majority of the work.

Difficulty of Getting Men—Usual Deficiencies:

None.

Solution:

Opportunity for Advancement:

Those who are satisfactory are certain to have a chance to qualify as stress analysts or detail design draftsmen.

ITEM V

Production Design, Drafting and Checking

453 Men—40%

Duties:

Make layout drawings and calculations to determine the actual size, shape, dimensions and manufacturing characteristics of each piece of the airplane.

Make working drawings of all details, assemblies, installations and auxiliary diagrams required to build the airplane.

Complete these in form to speak for themselves in hands of remotely located workmen.

Check working drawings for completeness, accuracy, soundness of design and feasibility of manufacture.

Apply expert knowledge in design specialty fields.

Qualifications Required:

Knowledge of materials and manufacturing practices used in modern aircraft construction.

Knowledge of drafting room practices and standards used in modern airplane construction.

Knowledge of government requirements affecting detail design and drafting.

Familiarity with government specifications for aircraft materials.

Ability at simple stress analysis for strength check of details.

Fundamental knowledge of mechanics and machine design.

Neat, accurate drafting.

Good practical working knowledge of trigonometry and descriptive geometry.

Specialized knowledge of one line, such as structures, surface controls, interior furnishings, installation of power plant, installation of electrical system, installation of hydraulic system, etc.

Training:

Two years college or equivalent in mechanical engineering and modern aircraft drafting.

Experience:

None required for simplest detailing from layouts.

Five or six years factory drafting room employment on Army and Navy aircraft work required to reach checker or design expert standing.

Difficulty of Getting Men—Usual Deficiencies:

Applicants trained in aircraft drafting room practice and shop practice are rare.

Solution:

Teach more design and drafting for production in the colleges in place of other less needed studies.

Introduce fundamentals of specialty design practices in college courses.

Opportunity for Advancement:
Eligible for promotion to preliminary design engineer or directly into administrative position.

ITEM VI

Tracing, Blueprint and Record Work

313 Men—27%

Duties:
Keep files of drawings, analyses, etc.
Make blueprints, tracings and other reproductions.
Compile specifications, material requisitions, parts releases, parts catalogs, maintenance instructions, etc.
Assist supervisors with miscellaneous office work.

Qualifications Required:
Skill at mechanical drawing, accuracy at simple figuring, ability at English composition, reasonable finger dexterity.

Training:
High School graduation.

Experience:
None required.

Difficulty of Getting Men—Usual Deficiencies:
None.

Solution:

Opportunities for Advancement:
If satisfactory, certain to have chance to qualify as detail draftsman.

ITEM VII

Administration, Supervision and Liaison

235 Men—20%

Duties:
Schedule Engineer:
Make and supervise schedules.

Group Engineer:
Handle administrative paper work in a given group as aid to group leader or project engineer.

C. A. A. Liaison Engineer:
Negotiate with C. A. A. for engineering approvals and licensing of the airplane.

Shop Liaison Engineer:
Coördinate between drafting room and production shops.

Group Leader:
Permanently head a large group of engineers and draftsmen working on a particular specialty applied to all current airplanes. (Example: Hydraulic system.)

Project Engineer:
Act as design consultant and administrative official in charge of all design drafting and release of a given model for the duration of its production contract.

Production Engineer:
Act as consultant on manufacturing methods and engineering economics.

Executive Assistant:
Act as expert on drafting, production, etc., as aid to chief engineer.

Chief Draftsman:
Act as foreman of the entire department.

Chief Designer:
Act as general design consultant and as design representative of the chief engineer.

Chief Engineer:
Act as executive head of all the department.

Assistant to any of the Above:
Aid in performance of same function.

Qualifications Required:
Thorough knowledge of airplane design, drafting room practice and shop practice.
Leadership ability.

Training:
Same as for Production Design. (These men are chosen from among suitable production designers.)

Experience:
Five to ten years factory drafting room employment on Army and Navy aircraft work.

Difficulty of Getting Men—Usual Deficiencies:
There are not many thoroughly seasoned men with leadership ability. Not a school problem.

Solution:
Same as for Preliminary Design and Development. (These men must be produced internally by accelerating the upgrading of present employees.)

Opportunity for Advancement:
Eligible for promotion to major executive of company.

It should now be evident that extremely few (only about two per cent) of our engineering department employees need post graduate study of aerodynamics. The other ninety-eight per cent require little real familiarity with this science. A lecture course giving a general resumé of what the aerodynamicist does, without going into all the particulars of how he does it, is adequate for their needs. Such a lecture course seems to build an adequate appreciation of the information emanating from the aerodynamics group for correlation with details of production design.

Equally apparent is the small percentage of employees requiring thorough knowledge of advanced structural analysis. Only six per cent of the total of men considered are employed in stress analysis and structural design work, and more than half of them perform their duties satisfactorily without advanced training covering the most difficult analyses. We see, then, that aerodynamics and stress analysis, the two present day main items of typical aeronautical engineering courses, are far less important to training for airplane factory employment than is popularly believed. Let us now consider the things that do constitute requisite preparation for the majority of placement opportunities.

Forty per cent of the men are engaged in production design, drafting and checking. Twenty-two per cent more are in preliminary design, development, liaison, supervision, and administrative work. These twenty-two per cent are promoted from the ranks of the former forty per cent, so the training need is the same for sixty-two per cent of the men. Before passing to a detailed examination of this training, note that we have now accounted for all but thirty per cent of the men. These thirty per cent comprise three per cent weight analysis men readily drawn from general engineering trainees, plus twenty-seven per cent tracers and clerks habitually recruited from the ranks of high school graduates. We are, therefore, well justified in concentrating the major share of our attention under the topic of "What the Aircraft Industry Expects of the Engineering College" upon the training needs for the sixty-two per cent of engineering department male employees who are responsible for getting the drawings made and supervising the functions of the entire department plus overseeing the construction of the airplane itself in the shops.

As we pass to a consideration of these product designers, we will leave the earlier paragraphs on "Training" found under the other items to speak for themselves without further amplification. The first thing the product designers need to know thoroughly is the product itself; that is, the airplane. They require a practical knowledge of its breakdown into manufacturing components, fa-

miliarity with parts nomenclature and nomenclature of various structural and mechanical types. They need to know the relationship of the foregoing to the conventions of modern airplane manufacture, beginning with distinction between parts habitually fabricated under the airplane factory's own roof and parts habitually purchased from outside. They must realize that not only do few, if any, American manufacturers of airplanes make their own engines, propellers, tires or instruments, but that none makes his own castings or forgings, etc. The considerations of engineering economy, involved in selection of work to be done at home versus outside production, are often extremely important.

After familiarity with the product itself comes familiarity with the office procedure of the typical engineering department operating under Army and Navy aircraft regulations. The product designers must know the customary group divisions and titles, must understand group functions and individual functions, and must appreciate the fact that all the work is performed by teams. Many newcomers are surprised to learn that no one man ever designs an airplane. The division of duties, authority and responsibility must be understood before the newcomer can fully take his place in the organization. The various steps necessary to accomplish the release of engineering information to the manufacturing units of the organization must be understood in order that drawings, reports, material estimates and other related information may be furnished in proper correlation. A study of a typical aircraft engineering department's organization and flow charts often brings out the comment, "There seems to be a lot of drafting involved." This is indeed true, and it must be recognized that drafting and engineering are so interworked in the airplane factory engineer's duties that it is seldom possible to distinguish between the two to a sufficient extent to say, "This man is an engineer, and that man is a draftsman." We must demand the death penalty for the bugaboo that drafting is to be despised by engineers. All of our engineers are draftsmen, and the great majority of our draftsmen are engineers.

It is very essential, therefore, that the study of aircraft drafting room practice be given adequate attention. A college professor, who recently spent a summer employed in our drafting room, announced his discovery of the reason why it had been difficult for even the best of his graduates to be of immediate value to us. Fortunately, he already knew that heavy demands at drafting would be made upon them, but the new discovery was that our drawings are three fold in nature and his graduates could handle only one of the three characteristics involved. These three are: PICTURE

OF THE PART, MATERIAL SPECIFICATION and WORK ORDER. This professor hit the nail right on the head. The usual graduate may be able to make an adequate picture in accordance with the rules of engineering drawing, but that is only one-third of the need. The blueprint from his drawing must go into the hands of a mechanic located blocks away in another building or miles away in another plant to speak for itself and accomplish a faithful reproduction in aircraft material without the draftsman standing over the workman's shoulder to explain what he means.

Each aircraft drawing specifies in careful detail the material to be used. Until the draftsman is acquainted with all the alloys of aluminum and steel used in modern aircraft and with all of the other common materials so that he can call for them by government specification number and indicate stock sizes corresponding to standard manufacturing practice, he cannot complete his drawing. He cannot even develop the design problem it represents until he is familiar with the Army and Navy standard aircraft hardware which must be utilized wherever applicable, and he must be able to designate such units by their complex coded part numbers.

We have so far considered just two of the three characteristics of the drawing; there still is the WORK ORDER to be considered. It is true that the blueprint will go into the shop accompanied by a work order from the proper administrative office of the factory, but much of the information for writing that order, in terms of quantities to be produced and routing through the factory, occurs basically on the blueprint. In addition, the blueprint must carry in exact detail such working instructions as reaming, countersinking, grinding, spot facing, machining to proper tolerances, sequence of operations with respect to heat treatment, finish to be applied and many other shop work considerations. The result is that aircraft shop practice, as well as drafting room practice, should be understood by the man who hopes to fit into a responsible position in the engineering department. Aircraft drafting room manuals, Army, Navy and Civil Air Authority design requirements, and government material specifications must be used as texts or reference data. Catalogues and engineering data books from material manufacturers may be referred to for familiarization with forms, gauges and stock sizes. The Army and Navy standard parts book, containing views of all parts complete with identification coding, is readily available to the schools. A study of the essentials of the work of the machine shop, foundry and sheet metal shop is vitally important. The sheet metal shop has to be considered in the light of aluminum alloy production with the emphasis on riveting. All theoretical studies along this line need to be largely supplemented by observations made in plant visits.

While versatility is highly desirable, and the broader a man is the better are his chances of rising high in responsibility, yet specialization often furnishes the necessary stepping stone toward employment. It is worthwhile for the college student in aircraft engineering to choose tentatively a design specialty among the main types of work; such as sheet metal structures, castings and forgings, parts for production in machine shop, power plant installations, design of electrical systems, hydraulic systems, control mechanisms, interior furnishings, etc. He may then, by extra reading on the side and extra personal effort toward contacts, highly develop his likelihood of fitting into an immediate opportunity upon graduation and likely enough command a better starting salary.

While all this has to do only with making and proper releasing of production design information on drawings, we are not unmindful that the sixty-two per cent of engineering employees directly affected includes practically all the leaders of engineering work. The point is that group leaders, project engineers, checkers, design specialty consultants and other key men of the engineering department, with few or no exceptions, are chosen from among the ranks of successful designers well versed in aircraft drafting room practice and aircraft shop practice. It may be said that for most of the better positions, far more important than a degree in aeronautical engineering is a thorough background in metal product manufacturing with specialization upon the methods and practices peculiar to government aircraft production.

It will be realized by now that many of the main items of training needs cannot be supplied by the usual college faculty. We have all heard how the best trade school training is given where the teachers are men from the industry. In this present case, it would appear that even more is required. The teachers for many of these subjects must, in order to handle them adequately and provide answers up to date, be more than men from the industry; they must be men *in* the industry. A few colleges located near some of the larger aircraft plants have already made arrangements with factory personnel for lecture series conducted by practical men borrowed off the job. These lectures are included in regular required work for graduation. This type of training is very effective and is, for many of the vitally essential drafting room practice and shop practice subjects, the only effective type known to date (outside of learning on the job, the hard way, in the factory).

The general conclusions we may then draw in summation of the original topic are about as expressed in the following two points:

1. The aircraft industry wants to have the engineering colleges gain a proper realization of the variation in job opportunities cor-

responding to different types of training, and then take definite steps to proportion their training accordingly.

2. It wants them to face the fact of heaviest demand for practical production training, mold the students' thinking in this direction and defer to any of their own institutions which are so situated geographically as to be able to handle such training in the only known way for effectively handling it; namely, through collaboration with some large factory which contracts to the government air services.

As an additional admonition, let us speak for the universal indoctrination of all students with appreciation of the value of continued study. It may well be pointed out that no matter what amount of training along the lines recommended above has been satisfactorily completed for employment, the successful engineer will continue indefinitely to study upon the side. It is the duty of the colleges to see that no graduate comes to us as an applicant with the attitude, "Now I am educated."

We thoroughly concur with the thought recently expressed by President Robert Gordon Sproul of the University of California when he said: "Nothing has handicapped the American educational plan more than the tendency of American citizens to think of schooling as a kind of vaccination against ignorance, and to consider that a concentrated dose of it in youth makes one immune for a lifetime. Actually, the immunity lasts only a few years, and unless it is renewed by periodic inoculations of study and thinking, one falls victim to a chronic type of ignorance which is often more dangerous than the acute form, because the patient, incompetent to recognize the symptoms, doesn't know he has the disease. We meet such chronic sufferers from ignorance everywhere. They look all right on the outside. They hold school diplomas or college degrees; they present a perfect picture of mental health; their voices are lusty; and they spout opinions as regularly as Yellowstone's Old Faithful. But inside, their minds are suffering from atrophy. Instead of thinking through problems in the light of all available facts, they merely supply a pattern of opinions based on facts that went out of date along with their yellow diplomas, and liberally garnished with prejudices that have accumulated in their minds like broken furniture in an attic."

DIMENSIONAL ANALYSIS IN ELECTROCHEMICAL ENGINEERING

By JAMES COULL * and J. ROGER SHIELDS †

Introduction

The methods of dimensional analysis have found widespread use in the solution of problems involving heat flow, fluid flow,‡ stress analysis and complex problems of general mechanics.§

Experimental observations on small scale models enable the naval architect or the aeronautical engineer, through the intelligent application of dimensional analysis, to effect full scale design with reasonable surety as to the final outcome.

In considering the various factors underlying cell design in electrochemistry, full advantage has not been taken of existing methods of dimensional analysis. It is not sufficient, for instance, to merely increase cell size a hundred or thousand fold, to achieve best results, yet this has been done in numerous cases.

That more work has not been done on cell design from engineering considerations, is probably due to the fact that electrochemical processes are probably the most efficient of our industrial chemical operations. Weber and York,|| citing the data of Mantell on the separation of hydrogen and oxygen, by the electrolysis of water, show a thermodynamic efficiency of fifty per cent for this process as against an efficiency of ten per cent for the separation of alcohol and water from solution by the purely thermal process of distillation.

In the methods of dimensional analysis it should be realized that the basic assumptions may be simply stated, are few in number and require no extensive mathematical knowledge for their fruitful application to highly complex situations.¶

Note: A considerable portion of the material of this paper is taken from an address given before the Pittsburgh Section of the Electrochemical Society, Feb. 27, 1940, by the first mentioned author.

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‡ "Collected Papers 11," p. 51, Osborne Reynolds.

§ "Structural Models—Part 1, Theory." U. S. Navy, *C. and R. Bulletin* No. 13, Lieut. R. D. Conrad, U. S. N.

|| *Trans. A. I. Ch. E.*, Vol. 34, 577, 1938.

¶ "Dimensional Analysis," P. W. Bridgeman, Yale University Press.

Basic Principles

All terms in an equation which describes a physical event must be capable of expression in the same system of fundamental dimensions. Thus, in the study of any problem a system of ultimate units must be chosen such that the quantities involved can be expressed in terms of these units.

As a matter of convenience all electrical quantities may be set up in terms of length, L, mass, M, and time, T, in the electromagnetic system, based on unit pole, or in the electrostatic system, based on unit charge.

Consistent solutions may be obtained with either system, provided that all quantities are expressed in terms of one system only.

Table 1 * lists some common electrical quantities and their corresponding dimensions in both systems of units.

Because the dimensional formulas of all quantities, with which we have to deal, are expressible as products of powers of the fundamental quantities, it becomes possible, however complicated the function, to rearrange the terms in such a way that they appear as groups of dimensionless arguments.

TABLE 5

Dimensions of Electrical Quantities

Quantity	Dimensions	
	Electrostatic	Electromagnetic
Quantity of Electricity	$M^{1/2}L^{3/2}T^{-1}$	$M^{1/2}L^{1/2}T^{0}$
Volume Density	$M^{1/2}L^{-3/2}T^{-1}$	$M^{1/2}L^{-3/2}T^{0}$
Surface Density	$M^{1/2}L^{-1/2}T^{-1}$	$M^{1/2}L^{-3/2}T^{0}$
Difference of Potential	$M^{1/2}L^{1/2}T^{-1}$	$M^{1/2}L^{3/2}T^{-2}$
Dielectric Constant	$M^{0}L^{0}T^{0}$	$M^{0}L^{-2}T^{2}$
Capacity	$M^{0}L^{1}T^{0}$	$M^{0}L^{-1}T^{2}$
Current	$M^{1/2}L^{3/2}T^{-2}$	$M^{1/2}L^{1/2}T^{-1}$
Current Density	$M^{1/2}L^{-1/2}T^{-2}$	$M^{1/2}L^{-3/2}T^{-1}$
Resistance	$M^{0}L^{-1}T^{1}$	$M^{0}L^{1}T^{-1}$
Resistivity	$M^{0}L^{0}T^{1}$	$M^{0}L^{2}T^{-1}$
Magnetic Pole Strength	$M^{1/2}L^{1/2}T^{0}$	$M^{1/2}L^{3/2}T^{-1}$
Magnetic Moment	$M^{1/2}L^{3/2}T^{0}$	$M^{1/2}L^{5/2}T^{-1}$
Magnetic Field Intensity	$M^{1/2}L^{1/2}T^{-1}$	$M^{1/2}L^{-1}T^{-1}$
Magnetic Permeability	$M^{0}L^{-2}T^{2}$	$M^{0}L^{0}T^{0}$
Magnetic Induction	$M^{1/2}L^{-3/2}T^{0}$	$M^{1/2}L^{-1/2}T^{-1}$
Self or Mutual Inductance	$M^{0}L^{-1}T^{2}$	$M^{0}L^{1}T^{0}$

Procedure

The variables involved must first be stated and then expressed in terms of a consistent system of units. The mathematical procedure may best be shown by the following examples. Equation for the

* "Dimensional Analysis," P. W. Bridgeman, Yale University Press.

charging current on a condenser,* when an A.C. voltage, having a frequency f, is applied.

Let
$$I = \text{current},$$
$$C = \text{capacity},$$
$$E = \text{voltage}.$$

Dimensions in electrostatic system:

$$I = M^{1/2}L^{3/2}T^{-2},$$
$$f = T^{-1},$$
$$C = L,$$
$$E = M^{1/2}L^{1/2}T^{-1}.$$

Let
$$I = kf^aC^bE^c,$$
$$M^{1/2}L^{3/2}T^{-2} = k[T^{-1}]^a[L]^b[M^{1/2}L^{1/2}T^{-1}]^c,$$
$$\Sigma M = 0: \quad \tfrac{1}{2} = 0 + 0 + \tfrac{1}{2}c,$$
$$\Sigma L = 0: \quad \tfrac{3}{2} = b + \tfrac{1}{2}c,$$
$$\Sigma T = 0: \quad -2 = -a - c.$$

Solving:
$$C = 1, \quad b = 1, \quad a = 1,$$
$$I = kfCE.$$

Pull exerted by a Magnet,†

$$F = \text{Force},$$
$$B = \text{Flux density},$$
$$S = \text{Area of poles}.$$

Dimensions in electromagnetic system:

$$F = M^1L^1T^{-2}; \quad B = M^{1/2}L^{-1/2}T^{-1}; \quad S = L^2.$$

Let
$$F = kB^dS^b,$$
$$M^1L^1T^{-2} = [M^{1/2}L^{-1/2}T^{-1}]^d[L]^b.$$

Solving
$$1 = \tfrac{1}{2}a,$$
$$2 = a,$$
$$1 = -\tfrac{1}{2}a + 2b,$$
$$a = 2, \quad b = 1,$$
$$F = kB^2S.$$

In the foregoing examples the number of fundamental equations and variables led to a singular solution.

However, in complex systems, where the number of variables exceeds the number of fundamental equations, the method does not

* "Elements of Electrical Engineering," A. L. Cook; John Wiley & Sons, 3rd Edition, p. 299.

† "Fundamentals of Electricity and Magnetism," L. B. Loeb; John Wiley & Sons, 2nd Edition, p. 268.

lead to a singular solution. In such cases the difference between the number of variables and fundamental units gives the number of arbitrary dimensionless groups which will appear in the solution.

The following example will clarify the above statements.

Streaming Potential *

Let $$E = f(k, \zeta, P, \eta, \kappa).$$

Derive an equation relating the variables.

$$E = k\zeta^a P^b \eta^c \kappa^d.$$

Parameter	Symbol	Dimensions in Electrostatic Units
Streaming Potential	E	$M^{1/2}L^{1/2}T^{-1}$
Potential Difference	ζ	$M^{1/2}L^{1/2}T^{-1}$
Hydrostatic Pressure	P	$M^1L^{-1}T^{-2}$
Viscosity	η	$M^1L^{-1}T^{-1}$
Conductivity	κ	$M^0L^0T^{-1}$

Therefore:

$$M^{1/2}L^{1/2}T^{-1} = k[M^{1/2}L^{1/2}T^{-1}]^a[M^1L^{-1}T^{-2}]^b[M^1L^{-1}T^{-1}]^c[T^{-1}]^d;$$

then

$$\begin{aligned} \Sigma M = 0: &\quad \tfrac{1}{2} = \tfrac{1}{2}a + b + c, \\ \Sigma L = 0: &\quad \tfrac{1}{2} = \tfrac{1}{2}a - b - c, \\ \Sigma T = 0: &\quad 1 = a + 2b + c + d. \end{aligned}$$

Solving in terms of b,

$$\begin{aligned} a &= 1, \\ d &= -b, \\ c &= -b, \\ \therefore \quad E &= k\zeta P^b \eta^{-b} \kappa^{-b}. \end{aligned}$$

and on grouping terms

$$E = k\zeta \left[\frac{P}{\eta\kappa}\right]^b.$$

The theoretical formula, as derived, is given as

$$E = \frac{D\zeta P}{4\pi\eta\kappa} \qquad \text{or} \qquad = k\frac{\zeta P}{\eta\kappa}.$$

The exponent b in the above equation is evidently equal to one. This may be shown experimentally by plotting the data of E v's $\dfrac{P}{\eta\kappa}$,

* "Theoretical and Applied Electrochemistry," M. deKay Thomson, The Macmillan Company, 3rd Edition, p. 71.

holding ζ constant. On a log-log plot the slope of the curve will be equal to b.

Applications to Cell Design

Situations might arise where the proper choice of the arbitrary dimensionless groups becomes difficult to make, because of the number of variables involved. Recourse is usually made to the application of the method of determinants, in order that a selection of the variables may be effected which will lead to a solution.

For example, in electrochemical oxidation of weakly ionized organic compounds, enough work has been done * to indicate the following factors have a significant influence on the rate of oxidation: electrode area, concentration, current density, shape factor, and velocity of circulation past the electrode.

A dimensional analysis of the problem may therefore be made.

Assume rate of oxidation R to be a power function of the above mentioned variables.

Then $$R = f[A^a, \Lambda^b, \phi^c, S^d, u^e],$$

where

area of electrode	$= L^2$	$= A,$
concentration	$= M^1L^{-3}$	$= \Lambda,$
current density	$= M^{1/2}L^{-1/2}T^{-2}$	$= \phi,$
shape factor	$= L^{-1}$	$= S,$
linear velocity	$= L^1T^{-1}$	$= u,$

$$M^1T^{-1} = k[L^2]^a[M^1L^{-3}]^b[M^{1/2}L^{-1/2}T^{-2}]^c[L^{-1}]^d[L^1T^{-1}]^e,$$

$$\Sigma M = 0: \quad 1 = b + \tfrac{1}{2}c,$$

$$\Sigma T = 0: \quad -1 = -2c - e,$$

$$\Sigma L = 0: \quad 0 = 2a - 3b - 2c - d + e.$$

Listing the coefficients in the above equations as determinants we have the following matrix:

	a	b	c	d	e
M	0	1	$\tfrac{1}{2}$	0	0
T	0	0	2	0	1
L	2	-3	$-\tfrac{1}{2}$	-1	1

From the above matrix it is seen that a solution to the above equations may be obtained by the selection of c, d, e as the variables. Thus, by use of the method of determinants, as shown above, a trial and error selection of the proper variables may be eliminated.

* M.S. Thesis, Chemical Engineering, University of Pittsburgh, J. R. Shields.

Therefore

$$c = 2 - 2b,$$
$$d = -4b + 2a + 2,$$
$$e = 4b - 3$$

or

$$R = k[A]^a[\Lambda]^b[\phi]^{2-2b}[S]^{-4b+2a+2}[u]^{4b-3},$$
$$\therefore \quad R = k\frac{\phi^2 S^2}{u^3}[AS^2]^a\left[\frac{\Lambda u^4}{\phi^2 S^4}\right]^b.$$

Conclusions

The usefulness of the methods of dimensional analysis has been illustrated by various applications to electrochemistry.

It is hoped that a more widespread use of this important tool may be made to electrochemical problems.

This is particularly true in case of cell design, involving electrochemical oxidation and reduction, where full size equipment is to be designed from small scale laboratory apparatus.

PROBLEMS IN SECONDARY EDUCATION THAT AFFECT ENGINEERING COLLEGES*

By FRANK B. LINDSAY

Assistant Chief, Division of Secondary Education, California State Department of Education

A week ago former President Herbert Hoover urged that "we work our machines and our heads harder" . . . "to definitely organize increase of our industrial efficiency and productivity. With sufficient increase of industrial efficiency," he said, "we could lower costs, lower prices, increase consumption and increase production. We could relieve the strain of priorities. We could take up some of the slack of unemployment. We could maintain our standard of living; we could prepare for the competition to come." This brief quotation illustrates how the nation is reawakening to the realization that its wealth is not gold buried in Kentucky, for instance, but in its resources of technically trained persons. And it helps to emphasize the dependence of the nation upon an adequate supply of capable engineers and skilled workmen if the United States is to win its war with the totalitarian powers. The shortages in trained personnel which today occasion bottlenecks in defense industries—for example, lack of tool and instrument makers, shipyard craftsmen, and aircraft supervisors—are due to a defective educational foresight that dates from the years when both capital and labor throttled the development of comprehensive vocational education. For neither manufacturers nor unions anticipated the rapidity of the industrial transformations effected by technology, which did not originate in the present emergency but are only accelerated thereby. And if industry is to meet the demands of defense or labor salvage its social gains, in the immediate future the task of the schools must be to repair deficiencies in trained manpower for the tasks ahead. Thus the legitimate interests of engineering colleges in secondary education extend beyond preparation for the several engineering professions to include also training for the chemical, electrical, and mechanical industries which derive from technology in all its branches.

The multiple social services of the public high school must be borne in mind when its program is examined. Recently in an ad-

* Presented at the meeting of the Pacific Southwest Section, December 27, 1940.

dress to the Phi Beta Kappa Society, Dr. Robert A. Millikan of California Institute of Technology called attention to the fact that, for the first time in human history, the people of this nation enjoy the advantages of considerable education since compulsory public schooling now assures almost every young person a high school education. On the other hand, Dr. Millikan pointed out, the effectiveness of public secondary schools is severely limited in two respects: there is little provision for the training of apprentices in industrial organizations; and a misguided public mistakes a college degree for a mark of purely social distinction without regard for competence in thinking. The absence of facilities to steer properly qualified youth into trades and industries, continued Dr. Millikan, has resulted in numerous high school graduates who are seriously deficient in capacities and in trainings requisite for success at institutions of higher learning presenting themselves to the colleges and universities for entrance. Then public pressure exerts its influence to induce the colleges to confer degrees upon individuals who somehow contrive to persist through the necessary years of residence and to accumulate specified credits and grade-points. It is Dr. Millikan's plea that high schools and colleges coöperate to secure a better selection of material for higher education and through mutual recognition of their distinctive problems jointly seek remedies for their present predicament. Only thus can secondary schools discharge their diverse social responsibilities and higher institutions maintain their obligations to uphold scholarly competence in research and engineering.

In this connection it must be noted that both public and educators have been confused by an illusion that passing courses represents mastery of knowledge. So long as thinking about secondary education is confined to reshuffling arrays of disconnected curricula pieced together in semester installments, little progress toward an effective school program is likely to result. Pressure for course credits has paralyzed common sense past perceiving that genuine knowledge consists in perception of relationships among important and true ideas organized into a permanent structure of thought. The problem of identifying suitable candidates for engineering training then involves far more than mere scrutiny of high school records; only a searching summary of a student's physical, mental, and moral resources can determine that character and extent of further education from which he may profit.

Any realistic approach to an appraisal of relations between secondary and higher education, and in particular between high school and engineering college, must take account of the actual conditions under which public schools operate. First among these is an economic structure which has no place for child labor in agri-

culture or industry. Between 1900 and 1910 a quarter of all boys aged 10 to 15 inclusive were gainfully employed. By 1920 only one boy in nine of that age group was at work; in 1930 but one in sixteen was so occupied. And the 1937 unemployment census showed that young persons aged 15 to 24 comprised more than thirty per cent of all unemployed persons. The mushrooming of defense industries may ultimately affect this picture but it has been the condition over a considerable period.

Partially to bridge the years between the attainment of physical maturity and admission into occupations, young people have turned to the public schools. In 1910 fifteen per cent of the high school age-group—youth aged 14 to 17 years—were enrolled in high schools; in 1930 more than half were at school; now it is about two-thirds. But mere enrollments do not, of course, tell the whole story. The genuine progress which has been achieved within one generation has been well summarized by Superintendent Donald DuShane, President of the National Education Association, in his address to the American Legion in national convention at Boston, on September 25, 1940:

In 1917, "The average citizen had less than a seventh-grade education; he had studied no civics, only a smattering of rudimentary history, had no vocational training, and no understanding of the fundamental principles of democracy or economics. . . .

"The average youth today has completed the second year of high school. He has done a great deal of reading and has a much better understanding of history and civics. He has had both manual and physical training. There has been an increase of over 350 per cent in high school enrollment since 1917, . . ."

This statement implies that the normal group today in American high schools is a non-college group; it shows that educators in the secondary area realize that the central objectives of high school training are citizenship, vocational adjustment, and the establishment of health-maintaining habits. But the presence in high school of so many pupils who lack facility in reading, in simple arithmetical calculation, and in abstract verbal thinking, has required the development of new material and different techniques for their instruction. Heretofore the high school had only to educate the docile, the ready, who thought they knew where they were going and would learn in spite of the shortcomings of teachers. Now the secondary schools are called upon to educate many who cannot profit from traditional subjects, who cannot derive knowledge from the usual printed textbook material, who have no idea what they want to do. The process of determining how to teach such people

has been stumbling and groping and at times maddeningly ineffective. But valuable discoveries about teaching have been made.

The first is that guidance is the first responsibility of the classroom teacher; only after counselling has been well done can effective teaching follow. Only unthinking acceptance by teachers and administrators of a rigid traditional curriculum and complacency with treadmill classroom performances could so long have blinded them to the fact that an educational institution's first duty is to know its students thoroughly. A second discovery is that the customary pattern of college preparatory subjects is not the sole route toward maturity. The majority of the high school population probably should not go to college, certainly are unfitted for professional training; yet every one of these who attains adult years will be a voter and workman and, if conscription continues, be a contributor toward the nation's security in a military sense as well. It is important that such persons understand the responsibilities of participation in the democratic processes of government; that they learn useful trades at which they may be successfully employed and well rewarded; and that they have loyalty to American ideals. The high school has equal obligation to train workmen for competency in applied technologies as to prepare pupils for college. And engineering colleges themselves must have these mechanics and machinists in industry if their own graduates are to have employment. Furthermore, the development of visual, auditory, and manual aids to instruction, essential for teaching shop courses, profitably supplement the printed page even for pupils who can learn from books. Sometimes schools have forgotten that education is a biological phenomenon which takes place in reaction to the total pattern of forces active in the environment. But sound and screen with the images of reality are coming to reinforce symbols in books. The topics of familiar courses are being reassessed and reinterpreted in terms of their utility in modern affairs. There are many bright spots in the picture of secondary education. The high school freshman today has more grasp of technology than had the college freshman twenty-five years ago: he has tinkered with an automobile; he has fooled with radio; has messed around with chemicals, probably has developed photographs; has modelled airplanes; and is familiar with numerous applications of science which a quarter of a century ago were only possibilities in the future. It is also to the advantage of engineering colleges that high school pupils receive instruction in habits of healthful living; gain knowledge of the social and political institutions through which technology, manufacturing, and business operate; and have acquired versatility in handling ordinary machines and some very complicated mechanisms.

But wide variations in schooling exist among the high school populations of states and regions which ought not to be ignored. Here in the Far West three-fourths of the high school age-group are at school. In seven southern states, however, fewer than one child in three attends high school. There also occurs overpopulation, a depressed plane of living, and little financial capacity to support public education. Many migrants to the western states come from sections where the expenditure per pupil for schooling is but a third or a fourth the amount devoted to elementary and high schools here. The 1930 census showed that 57 per cent of the residents of California had been born in other states; for Arizona, Nevada, Oregon, Utah, and Washington the percentages are the same or higher.

Another factor to be weighed in estimating the services of the high school both as a social agency and as a source of supply of students for higher institutions is the professional training of the teachers. In 1930–31 approximately 60 per cent of all senior and four-year high school teachers had the bachelor degree; twenty-nine per cent had some graduate training. The Pennsylvania Study showed that 15 per cent of high school seniors majoring in science were superior in grasp of their field to 40 per cent of college seniors who intended to teach science after graduation. No wonder the President's Advisory Committee on Education observed that the conventional high school curriculum has become largely unintelligible to pupils, parents, and the public!

Since the present discussion relates particularly to relations of secondary schools to engineering colleges, it will suffice for this purpose to examine offerings in mathematics and science commonly found in California high schools. As the high schools differ markedly in size, there will likewise be variations in the subjects to be found in the school programs. Thus, there are twenty high schools with enrollments under fifty; another thirty-three have enrollments between fifty and a hundred. Altogether there are nearly one hundred fifty high schools whose student bodies each comprise less than two hundred fifty pupils.

In all schools, however, the conventional courses in science are prevalent. Recently 337 high schools situated outside the two largest cities have been examined by the Division of Secondary Education for their science courses. (These represent more than three-fourths of California public high schools.) Ninth grade general science occurs in three-quarters of these schools. Biology and chemistry are the tenth and eleventh grade sciences, respectively, in nine-tenths of the schools. Physics is the twelfth grade science in four-fifths of them. Advanced physical science, a combination

of topics from chemistry and physics which it is claimed is more adapted to the needs for general scientific knowledge by most youth today, is offered in one high school out of five. In the 144 smaller high schools with enrollments under 250, general science occurs less frequently; biology and chemistry are offered in only four-fifths of them; and physics in not quite two-thirds of these schools. Advanced physical science is given in only one of seven. But in the high schools of middle-size, whose enrollments vary between 250 and 950, biology and physics are science offerings in nine-tenths of the number; chemistry is given ninety-five per cent of the time. Physiology, photography, and botany appear in only one high school in ten, and those the larger ones.

The course in ninth-year algebra, for so many years a standard requirement for first year high school pupils, has been found inappropriate for many. A number of pupils have not developed sufficient mastery of arithmetic operations to conduct algebraic manipulations with confidence; others have not matured enough to succeed in making the abstract generalizations demanded by algebra; and many probably have no need for formal algebra in preparation for their vocational objectives. In consequence, a course has become popular which is usually called general mathematics. It is much more than a mere review of arithmetic; it is a means for effecting guidance into mathematics. During the first semester the pupils can be sorted out: in general those who are ready for algebra and want it for college are shortly introduced to the subject; others can be held for further training or even deflected from additional mathematics courses if there appear little likelihood of their profiting from such work. About two-thirds of California high schools have general mathematics. This course should not be regarded as a weakening of the mathematics offerings but as an important feeder course through which pupils capable of college preparation can be located and subsequent sections of mathematics strengthened by the exclusion of the unready and incompetent.

There is a general movement afoot in high schools to separate in every field elements needed by all pupils from technical content important for specialization. Abilities to understand concepts of statistics, of percentage, and spatial relations are needed by every one. Formal algebra and geometry may not be so necessary nor possible for all pupils to acquire. Los Angeles City schools have found that not more than fifteen per cent of their high school pupils go to college and only one-half of one per cent enter engineering. Therefore it has been proposed that algebra, geometry, and advanced high school mathematics be given wholly in senior high school where college preparatory pupils may be grouped together. It is

hoped that the absence of numbers who would be failures in any case may enable the more capable to master mathematics more fully and more quickly since teacher and class time need not be dissipated in vain attempts to instruct the very dull. The greater maturity of the pupils, it is felt, will be helpful in accelerating learning. Graduates from the Los Angeles City schools who major in mathematics will then enter college fresh from intensive study of the subject.

Another promising approach to reorganization of mathematics in high school has been suggested by the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics in the recent publication, "The Place of Mathematics in Secondary Education." Grade placement of topics and their grouping into areas have been proposed. Essentially the scheme is greatly to enrich the mathematics offerings so as to make them useful for many more pupils than traditional sequences have been. But it must be clearly realized at the outset that an enlarged and enriched program is premised upon the effectiveness of mathematics teachers who must not only have greater mastery of mathematics than often has been true but also accurate knowledge of adolescence so that the urges and vagaries of children can be seized upon and redirected fruitfully. To develop insight and to link mathematical principles to their industrial applications the utilization of geometry in specific trades, for instance, should be pointed out. The indispensable services of mathematics for achievement in many occupations have been nullified by the ignorance and unfamiliarity of mathematics teachers with techniques and procedures in shops and manufacturing establishments. Teachers whose acquaintance with mathematics is limited to chalk and blackboard inhibit the development in pupils of manual dexterity and appreciation of spatial relations.

Higher institutions are interested in receiving students who demonstrate power in abstract thinking and who have facility in the manipulation of equations and concepts in number and space. The techniques by which high school pupils can most readily attain such skills must largely be developed by classroom teachers in secondary schools. But college faculties can encourage them in their efforts through being aware of the complexity of the responsibilities of secondary education to the public and by having sympathetic understanding of their attempts to discharge their obligations. High schools have the duty of instructing young people not only for citizenship but also for vocational competence and adequate home membership. One important aspect of this responsibility is preparation of qualified persons for advanced training at higher institu-

tions. The task of the high schools is to locate capable youth and segregate them into special groups for rigorous training. In particular, attempts are going forward to devise courses in science and mathematics which may serve on the one hand to improve the participation of young adults in political and economic relationships and also on the other hand constitute a sound basis for later intensive training at the colleges. Learning students is prerequisite for teaching them. And the identification of the capable is a joint responsibility of high schools and colleges. Their selection should not be based solely on any one pattern of high school subjects nor single entrance examination but demands continued observation and reappraisal as the pupils are successively exposed to differentiated treatment especially in science and mathematics.

NEW MEMBERS

CONDON, EDWARD U., Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa. E. B. Roberts, F. L. Bishop.

CUTSHALL, CHESTER S., Associate Professor of Applied Mechanics, Purdue University, Lafayette, Ind. Seibert Fariman, S. D. Chambers.

GIFFT, HOWARD M., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa. O. A. Olson, L. O. Stewart.

HOFFMAN, OSCAR, Instructor in Structural Engineering, Fenn College, Cleveland, Ohio. B. H. Bush, J. C. Nichols.

IRESON, WILLIAM G., Instructor in Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. P. T. Norton, J. B. Mahaney.

LERNER, SAMUEL, Instructor in Civil Engineering, Brown University, Providence, R. I. S. J. Berard, W. R. Benford.

LOTT, ARWYNE O., Instructor in Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. P. T. Norton, J. B. Mahaney.

SIBILA, KENNETH F., Instructor in Electrical Engineering, University of Akron, Akron, Ohio. J. T. Walther, P. C. Smith.

STEVENSON, WILLIAM D., Instructor in Electrical Engineering, Clemson Agricultural College, Clemson, S. C. S. B. Earle, S. R. Rhodes.

WARREN, JOEL, Instructor in Mechanical Engineering, Brown University, Providence, R. I. S. J. Berard, W. R. Benford.

181 new members this year.

THE ENGINEER IN THE FEDERAL SERVICE*

By E. J. STOCKING

Principal Examiner (Engineering), U. S. Civil Service Commission

The recruitment of personnel for the executive branch of the Federal government started with the inauguration of George Washington as the first executive head of the newly formed nation. I do not know who was the first engineer employed, but history tells us that President Washington, who had considerable reputation as an engineer, very early in the life of the nation employed Major L'Enfant to design and lay out the new capital city.

In making his appointments, President Washington tried to appoint only those who had demonstrated their ability to perform certain duties. Washington's acquaintance with the country appears to have been quite extensive, because of his activities during and following the Revolution. He sent out letters of inquiry to prominent persons of his acquaintance relative to the qualifications of applicants for Federal positions. However, without the ready means of communication that the electrical engineers have made available to the modern world, and with many outlying and sparsely settled communities to consider, it was difficult for the early Presidents to know much about the qualifications of the various applicants for positions. In an effort to obtain worth-while information, they often referred names of applicants to those Congressmen who might be expected to know something of the applicants' character and ability. This practice was not originally intended as a political gesture, but it did not take long for it to develop into a political clearance system and as a result many of the appointments were given to members of the party in power.

Thomas Jefferson, the third President of the United States, proceeded to remove quite a few of the Federalists who had received appointments in previous administrations and as vacancies occurred he filled them by members of his own party. Jefferson's own policy was a "redressing of the balance," a mild form of appointment on the basis of party loyalty plus ability. His policy was not based on party affiliation to the extent demanded by some of his followers, and by no means to that extent which was introduced in 1829. Thomas Jefferson is often given credit for first stating examination

* Presented before the Middle Atlantic Section, S. P. E. E., University of Delaware, May 4, 1940.

requirements, or setting up specifications that applicants must meet in order to obtain employment in the Federal service. Jefferson's requirements, while not published in an official announcement, were to be applied to all applicants and consisted of meeting the qualifications implied in the following three questions: "Is he honest?" "Is he capable?" "Is he loyal to the constitution?" However, Jefferson did not consistently apply his three criteria, but did indicate that he hoped the time would come when these would be the only criteria.

Jefferson's gauge of merit held in a general way for the first forty years although, of course, complete continuity of service did not exist. For a period of some fifty years, starting about 1830, government personnel changed with the political winds and partisan removals as well as appointments became a part of the accepted order. Senator William L. Marcy of New York in making a speech during that period coined the phrase, "To the victors belong the spoils." His speech was simply a frank avowal of affiliation with the spoils system of his native State and a statement of the rules of the game as he and Van Buren saw them.

In 1853 and 1855 Congress made an effort to improve conditions by requiring that clerks in Washington take a "pass" examination given by the head of the department. Because incumbents were only required to pass the test and as the "pass" examinations varied according to the person to be examined rather than the position for which he was examined, it put little restraint on personal and partisan influences and in a few years it was discontinued. The multiplication of offices resulting from the Civil War clearly showed the need for a change and in 1871 Congress vested authority in President Grant to ascertain the fitness of candidates. President Grant then appointed our first Civil Service Commission. A system of competitive examinations was established, but before the plan could be applied very widely Congress cut off appropriations and there remained little to show for the effort.

The cause, although subjected to ridicule and opposition, was not entirely forgotten and President Hayes aided the cause to a considerable degree by his Executive orders concerning the New York Customs Service. Over a period of years, sentiment was gradually built up for the establishment of a competitive merit system for Government employees.

It has been stated, with what degree of truth I do not know, that it took the assassination of President Garfield by a disappointed office seeker to get a civil service bill through Congress. Harper's Weekly, the best pictorial weekly of that period, consistently intimated to the public that the assassination of President Garfield was the result of the spoils system. Its writings, together with those of

other newspapers and periodicals, appear to have had an influence on the public, and consequently on the Congress.

Whatever the reasons may have been, Congress did pass the Civil Service Act on January 16, 1883 (which was drawn up by Dorman B. Eaton and presented by George H. Pendleton, Chairman of the Senate Committee on Civil Service Reform), and thereby established a basis for a career system in the Federal Service.

All positions were not immediately included within the competitive service and it was not until 1888 that many engineering positions in Washington, D. C., became subject to recruitment through competitive procedures. The Executive order of May 6, 1896, so modified the civil-service rules and regulations as to permit large numbers of positions in the field service (that is, Federal positions outside of Washington) to be included in the competitive classified service. A number of engineering positions then established and also a very large number of similar positions established at later dates as the work of the Government in the field of engineering expanded were included in the classified service as a result of the Executive order of May 6, 1896.

Lieutenant Colonel Alexander Mackenzie, U.S.A., in commenting on the effect of that Executive order on the personnel in the Engineer Department at Large made the following statement before a Senate Committee on January 24, 1898.

> While the issuance of the President's order of May 6, 1896, was under consideration, I gave attention, at the request of the Chief of Engineers, to the probable effect of extending the classified civil service to the Engineer Department at Large. In a memorandum submitted, while expressing most emphatically my firm belief in the principles of civil service, I called attention to certain restrictions of the law which I feared would result in embarrassment to the important works being carried on under the direction of the Chief of Engineers. Later experience has shown me that such fears were to a large extent imaginary and resulted mainly from a misunderstanding of the law.
>
> When the President's order was promulgated, Capt. George W. Goethals, Corps of Engineers, and myself were detailed by the Secretary of War for consultation with the Civil Service Commission, with a view to formulating a system and special regulations for applying the civil-service law to the Engineer Department at Large. Many difficulties were at first experienced, but such have been to a large extent overcome by the wisdom of the Commission and its earnest desire to make civil service a benefit to our work.
>
> The general system under which civil service is applied to the Engineer Department at Large is given in Circular 13, issued by the Chief of Engineers, August 10, 1897. This system is of course not perfect, and as experience is gained modifications will undoubtedly be found necessary and desirable; but it appears to me comparatively simple, and, in my opinion,

preferable to the method of appointment in effect previous to the application of civil service. From the circular of the Chief of Engineers above mentioned I quote as follows: "Under the system now agreed upon it is believed that no difficulty will be experienced by officers or agents in securing the best and most suitable employees, and that so soon as the present regulations are fully understood the benefits of the application of the civil-service law and rules to the Engineer Department at Large will be fully acknowledged."

There are a few officers of the Corps of Engineers whose unfavorable impressions of the civil-service law, formed in advance of a full knowledge of its requirements, have not been changed by experience, but correspondence with officers leads me to believe that the large majority prefer a competitive merit system of securing employees, rather than one in which personal opinions or wishes are to control.

The Classification Act was passed in 1923 and as a result positions within the departmental service were allocated, on the basis of duties performed and responsibilities assumed, into services, classes, and grades. The two services of most interest to the engineering profession are the professional and the subprofessional. Of course, engineers are interested in all services and classes to some extent because in performing their duties they have to deal with mechanics, operating enginemen, clerks, administrators, and personnel officers. However, education and experience in the field of engineering qualify persons to fill professional and subprofessional engineering positions rather than other types of positions.

Previous to the passage of the Classification Act of 1923, the title and salary of a position might give a hint as to whether the position was professional or subprofessional, but were no true criteria, and so it is difficult to say just how many professional engineering positions existed during the early days of civil-service administration.

While the present Classification Act applies only to the departmental service in Washington, the various Government agencies are directed by an amendment to the Classification Act to promulgate field classification systems based upon the same principles and procedures as found in the departmental system. These classifications are not reviewed by the Civil Service Commission and, therefore, the same standards are not always maintained, but the system has been found helpful to personnel administration. As a result it is possible today to get more accurate data on the number of persons holding professional engineering positions in the Federal Service than it was previous to the passage of the Classification Act.

John F. Hayford, Chief of Computing Division Coast and Geodetic Survey, in a paper presented before the Society for the Promotion of Engineering Education in 1905 stated,

I shall deal only with the opportunities for graduates in civil, mechanical, electrical and mining engineering. The opportunities for engineers from West Point will be omitted. They are closed to others. The Isthmian Canal work will not be included, as I did not succeed in becoming well posted in regard to it. The positions for which the pay is less than $700 per year are also excluded from statistics to be given. There will be included all positions to which the engineering graduate may hope to rise by merit, not simply the entering positions.

The statistics given are believed to be sufficiently accurate for the purpose and are expressed in round numbers. In cases of disagreement between different authorities the figures which make the Government service less attractive are used.

Within the limits stated there are 2,600 opportunities for engineering graduates in the Government service. For 46 per cent of these positions the pay is between $700 and $1,400 per year; for about 32 per cent, from $1,500 to $1,900; for 18 per cent, $2,000 to $2,900; for three per cent, $3,000 to $3,900; and for nearly one per cent, $4,000 or over. These figures are for salary only, they do not include allowances for expenses, subsistence and quarters furnished, etc., which are received by many.

There are nearly 700 opportunities under the Chief of Engineers of the Army for engineering graduates. This force includes 180 assistant engineers or superintendents, 150 junior engineers, and 70 draftsmen. The lake survey is a part of this group of 700.

There are more than 500 opportunities in connection with navy yards and naval stations. This includes 40 civil engineers and constructors, and nearly 400 draftsmen.

In the engineering force of the Reclamation Service, under the Geological Survey, there are 360 engineers. This service is growing very rapidly and will probably continue to do so for several years. Hence, it furnishes the best chance in the Government service for the rapid advancement of unusually able men, with the possible exception of the Panama Canal work.

Three hundred patent examiners are employed in the Patent Office.

In the Coast and Geodetic Survey there are 140 opportunities for engineering graduates; 90 in the field force, 20 as draftsmen, and 20 as computers.

There are 130 opportunities under the General Land Office.

The remaining 500 opportunities are scattered through the service. The largest groups are in the Topographic Branch of the Geological Survey, in the Revenue Cutter Service in charge of marine engines, under the supervising Architect as superintendent, and in the engineer department of the District of Columbia.

New appointments are being made at the rate of about 200 per year to repair the waste in the force of 2,600, and to produce the steady expansion which is normally in progress.

Nearly all of the 2,600 positions are in the classified service, to which entrance is guarded by the Civil Service Commission.

At the present time there are employed by the Federal Government some 22,000 professional engineers and architects of which approximately 13,000 are in the competitive service. Approximately eighty per cent of the 9,000 outside the classified service are employed by those agencies generally considered to have an emergency status such as the P.W.A. and the W.P.A.

The following table shows the approximate distribution of engineers employed by the Federal Government at the present time.

APPROXIMATE NUMBER OF PROFESSIONAL ENGINEERS AND ARCHITECTS IN THE FEDERAL SERVICE AS OF OCTOBER 1, 1939

Department	Classified positions*	Unclassified positions	Total
Agriculture	1,546	630	2,176
Civil Aeronautics Auth.	156	36	192
Commerce	283	171	454
Federal Works Agency †	1,417	5,715	7,132
Federal Power Com.	79	137	216
Interstate Commerce Com.	89	—	89
Interior	2,620	397	3,017
Maritime Commission	112	8	120
Navy	2,737	71	2,808
Treasury	154	24	178
War	2,993	16	3,009
Total	12,186	7,205	19,391‡

* Classified positions are those which are subject to the Civil Service Act and rules. They are also popularly called "civil-service" or merit system positions.

† P.W.A.—3,112 unclassified engineers. W.P.A.—1,800 unclassified engineers.

‡ Not a complete total as data was not available for all agencies.

You will note that Mr. Hayford indicated that there were approximately 2,600 engineering positions in the classified service in 1905. The above compilation shows that three departments now have more than that number of classified engineering positions and it also indicates that during the past thirty-five years there was an increase of 480 per cent in engineering positions.

What are all of these engineers doing day after day? How are they employed? What services do they render? What are their aims, ideals, and activities? Naturally there is no profit motive connected with engineering activities of the Federal Government—the fundamental motive being one of service. However, it is true that a number of Government engineers are employed on production problems. The Navy Department has a large force engaged in the production of ships while both the War and Navy Depart-

ments manufacture ordnance material and other naval and military supplies. The T.V.A., the Reclamation Service, etc., manufacture power in connection with their other functions. A large number of technically trained persons are employed in the promotion, development, protection, and conservation of the natural and other resources of the nation. Many are employed in such activities as: flood control, forest preservation, irrigation and drainage, soil conservation and erosion control, ground water studies, and the improvement and maintenance of wild life preserves. Public works construction and its encouragement, promotion and coördination gives active professional employment to engineers interested in continental highways, canals, rivers, harbors, rural electrification, power development, Federal buildings, and housing activities. Others devote their attention to public health problems such as epidemic control, prevention and control of stream pollution, preservation of foods, promotion of sanitation, vermin and rodent control; and also the collection and dissemination of vital information on occupational hazards, safety measures, milk codes, sanitation practices, and disease prevention.

Certain Federal bureaus and agencies are primarily concerned with the problems of research, development, and standardization. Such agencies employ engineers in defining units of measurement, standardizing processes and products, standardizing tests, methods, and procedures, calibrating measuring instruments and apparatus, writing standard or model specifications, devising new and better uses of materials, utilization studies of waste material and other products, and also in scientific investigations in every field of engineering. The work of these agencies has had considerable influence on engineering designs, specifications, and procedures (and it may be expected will have still greater influence in the future).

The enforcement and informational activities of the Federal Government relative to safety laws and educational programs, labor laws, valuation of industrial plants, regulation of utilities, air-transport regulations, acquisitions and appraisals, and building specifications require persons with engineering education, training, and experience.

The national defense program demands the continuous service of a large technical staff in the design and construction of fortifications and barracks; the modernization of ordnance and the development of new machines for defense purposes; the development of aeroplanes for war purposes; the construction and design of ships, navy yards, and docks; the development of harbor facilities; and the conducting of studies leading to the quick coördination of industrial efforts and defense programs in time of war. At the present time, because of the keen competition between the Government

and industry for competent personnel in the field of marine engineering and naval architecture, the Civil Service Commission is having difficulty in obtaining sufficient highly qualified marine engineers, naval architects, and ship draftsmen.

In discussing the functions of engineers in the Federal Service, I have tried to avoid too many statistics, and have not attempted to include all of their manifold activities. My thought is that general information will give a sufficiently clear idea of the important part engineers have in the executive branch of our modern complex government.

Referring again to the statements of John F. Hayford, you will remember that in 1905 new appointments were being made at the rate of about 200 per year. As might be expected, the present rate is far in excess of that figure; in fact there have been appointed from the last junior engineer register (established in July 1939) over 700 recent graduates. In addition, there are now on certification from that register the names of a large number of persons, many of whom will receive appointments. The table below indicates the number of professional engineering appointments that occurred for the ten-year period, 1929 to 1939.

Fiscal year ending, June 30	P–1	P–2	P–3	P–4	P–5	Total
1929	235	56	40	2	1	334
1930	300	84	50	13	11	458
1931	316	164	106	16	7	609
1932	216	77	49	11	2	355
1933	34	19	14	0	0	67
1934	74	49	21	2	3	149
1935	85	55	29	6	8	183
1936	283	122	87	31	6	529
1937	266	62	61	10	1	400
1938	215	48	12	2	1	278
1939	785	259	105	32	2	1,183
	2,809	995	574	125	42	4,545

Note.—This compilation represents appointments made from the register and is exclusive of any noncompetitive promotion or classification cases, and refers to professional engineering positions only. It does not include any subprofessional positions such as draftsman, engineering aid, scientific aid, etc.

P–1 positions are junior engineer positions paying an entrance salary of $2,000 a year. P–2 positions are assistant engineer positions paying an entrance salary of $2,600 a year. P–3 positions are associate engineer positions paying an entrance salary of $3,200 a year. P–4 positions are engineer positions paying an entrance salary of $3,800 a year. P–5 positions are senior engineer positions paying an entrance salary of $4,600 a year.

Complete data are not yet available for this year but undoubtedly the figures on engineering appointments will equal, if they do not exceed, those of 1939.

The number of classified subprofessional engineering positions greatly exceeds the 13,000 professional positions and the problem of recruiting for technical positions is indeed a difficult one. A tremendous increase in the number of applications for technical positions has occurred in recent years because of the keen competition for employment and because of the increased interest in governmental affairs.

Approximately 10,000 competed in the recent junior engineer examination held on April 6 of this year, and a recent examination for various grades of engineering aid produced approximately 25,000 applicants. Of these 25,000 applicants, 21,662 actually competed in the written part of the examination. Examination announcement No. 67 of 1939 for various grades of professional engineering positions yielded 10,259 applications, while a more recent announcement for draftsman positions resulted in 11,045 applications being filed.

I cite these few figures (I could cite many more) simply to indicate the magnitude of the recruiting job with which the Commission has to contend.

The handling of large numbers of applications is, however, only one phase of the recruitment problem. There are, in addition, the problems of preparing examination announcements, rating schedules, and examination questions, the obtaining of examination rooms, the rating of assembled (written) examinations, the rating of applications resulting from unassembled examinations, and always the answering of a large volume of correspondence.

When vacancies occur they need not necessarily be filled through the procedure of open competitive examination. They may be filled by promotion of persons within the service, by transferring employees from one department to another, or by reinstating, *i.e.*, rehiring a person with a good record who previously worked for the Federal service and who resigned and wants to come back into the service. However, the open competitive method of filling vacancies, I presume, is of most importance to this group.

Once it is determined that personnel needs are to be met through open competition, the next step consists of planning the tests. The Commission plans the examination in collaboration with the personnel officials of the departments which will use the list of eligibles established as a result of the examination. After a careful study and an analysis of the duties and responsibilities of the position have been made, the Commission determines what educational and ex-

perience requirements are needed to insure qualified eligibles and then proceeds to announce the examination in printed form to be circulated to the newspapers, professional publications, and to all first- and second-class post offices throughout the country.

Examinations may be of the assembled type or of the unassembled type. The assembled type of examination is one in which candidates are assembled in an examination room and take a written test. The unassembled type of examination is an examination that does not require candidates to assemble for the purpose of taking a written test but is based instead on an appraisal of the extent and quality of the education and experience of the applicant. An oral examination is also sometimes given as a supplementary part of either the assembled or the unassembled type of examination.

In the engineering field, the Commission holds examinations for two large groups of positions. One group, generally called the subprofessional group, includes such positions are surveyor, inspector, engineering aid, draftsman, etc. The other group is the professional group and includes such positions as junior engineer, assistant engineer, associate engineer, engineer, senior engineer, principal engineer and head engineer. The entrance salary for the subprofessional group ranges from $1,020 to $2,600 a year, whereas the entrance salary for the professional positions ranges from $2,000 to $8,000 a year. There are a few engineering positions in the classified service paying an annual salary greater than $6,500, but such positions are ordinarily filled by promotion rather than by open competitive examination.

One of the things to be decided in planning an examination is whether the examination is to be of the assembled or the unassembled type. The rules and regulations of the U. S. Civil Service Commission provide that examinations be assembled whenever practicable and the Commission, therefore, holds the objective written examination when it appears probable that the assembled type: (1) will produce qualified eligibles in sufficient numbers to meet the needs of the service; (2) can be adequately prepared and rated without undue delay; (3) can be held at reasonable cost; (4) will better measure the qualifications of the applicant. The assembled examination is generally used in connection with the recruitment of junior engineers, engineering aids, and engineering draftsmen. Subprofessional positions seldom require applicants to show formalized technical education, although such education is often permitted as qualifying in lieu of experience. Professional positions, particularly those positions of a research nature or those positions in which it is necessary to have an intimate and working knowledge of the fundamental sciences of engineering, usually require a stated amount of formal education for admittance to the examination.

As the higher grade professional, administrative, and executive engineering positions all require a certain amount of specialized experience over and above formal education, the unassembled type of examination is ordinarily used for recruiting for such positions. Numerical ratings are based on the education and experience shown and on such corroborative evidence as the Commission obtains from confidential vouchers sent to former employers and references of the competitors.

The Commission and the various Federal agencies are just as anxious to obtain the very best of the engineering students as is industry. Therefore, young engineers who desire employment in the Federal Government are encouraged to apply for the junior engineer examination or for some of the subprofessional engineering examinations. Should it not be possible to obtain an original appointment in a professional position, a person accepting a subprofessional position may later, upon the occurrence of appropriate vacancies or the establishment of new positions, be promoted to a professional position providing the appointee's work is sufficiently satisfactory to warrant such promotion.

I wish to dwell briefly on the unassembled examination because of the important part it has in competitive civil-service recruitment for higher grade positions. For a number of years, I have been engaged as a professional examiner in preparing and rating examinations in the engineering field, and I have noted in reviewing applications that competitors constantly try to sell themselves, that is, they explain what they can do, tell how good they are, etc. For objectively rating education and experience, a knowledge of what the applicant actually has done is more essential than what he believes he can do. Before filling out an application form, therefore, it is wise for applicants to read very carefully the examination announcement and make every effort to answer all questions completely and in detail. When describing experience in an application form, an applicant should realize that rating examiners and appointing officers are more interested in clear-cut statements of duties actually performed, responsibilities assumed, and accomplishments attained than they are in personal opinions of one's worth.

In some examinations the Commission must write highly specialized experience requirements into the announcement in order to be sure of obtaining qualified eligibles for the position. Many competent engineers often apply and their applications must be "cancelled," not because they are not competent engineers but rather because they do not have the specialized experience needed for that particular position. Such engineers should not accept this "cancellation" as a reflection on their ability as an engineer—it is

not intended as such by the Commission and in later examinations when requirements are modified so as to recruit for other positions, it may be possible to accept their experience as qualifying and give them an eligible rating.

In closing, I wish to point out that engineers in the Federal service are much the same as those outside the service. Many of them maintain affiliations with the various professional societies and are generally accepted by the profession. Some are constantly contributing to the engineering literature of the day, and the engineering leaders in the Federal service can point to outstanding accomplishments in their respective fields. The Government engineers appreciate the opportunity of meeting with their fellow engineers in order to discuss mutual problems and to formulate engineering philosophies that will lead to future professional development. The U. S. Civil Service Commission and all true professional engineers in the service welcome the competition of top-notch engineers and engineering students in examinations for the competitive classified service.

FINAL REPORT COMMITTEE ON ENGINEERING RESEARCH 1939–1940

WHITHER GRADUATE RESEARCH? . . . GRADUATE ENGINEERING THESES SUBMITTED IN AMERICAN SCHOOLS IN 1939

The Committee on Engineering Research has compiled the titles of graduate engineering theses which were submitted in engineering schools in the United States and Canada during 1938–39. Data were submitted by 73 colleges and universities and a total of 1141 thesis titles were submitted to the Committee for consideration. Statistical summaries by schools are shown in Appendix 1 and the complete list of theses is given in Appendix 2. Thesis titles were first classified into six major groups according to subject matter—chemical, civil, electrical, and mechanical engineering, engineering mechanics and mathematics, mining engineering and allied fields.

The thesis titles in each of these major divisions were submitted to the committee members and through them to subcommittees for classification and analysis according to (1) subject matter, (2) function or type of work, and (3) statistically in various ways. These thesis titles classified according to major fields and further subdivided according to schools may be of considerable value to research workers as a kind of yardstick by which each person directing graduate research may take stock of his own activities in the field. Admittedly in themselves, the thesis titles give only a rough index of the problems investigated and little or nothing regarding such points as thoroughness and over-all contributions to the advancement of basic engineering science or art.

The titles of unpublished graduate theses may reflect the very beginnings of fundamental research in organized form. The mere listing and classification of these titles may supplement information desired in emergency training and research programs as to types of projects, laboratory facilities, and direction and working personnel.

Practice among the several schools varies widely as to the reporting of information on unpublished theses. Often information on thesis titles was available directly from deans of graduate schools in the several colleges and universities. Sometimes however the information could be obtained only by direct communication with the deans of the schools of engineering and sometimes even with department heads under whose immediate supervision the work was done.

The commencement program was the usual source of printed information concerning graduate thesis titles in engineering. Some schools issue annual lists of publications and research, and others periodically issue abstracts or digests of all graduate theses submitted in partial fulfillment of advanced degrees. A few compilations of thesis titles and of abstracts covering engineering researches completed over a period of years have been published by the colleges.

General reviews of the lists of thesis titles as adapted from subcommittee reports follow:

Chemical Engineering.—An analysis of graduate thesis titles in Chemical Engineering for 1938–39 showed the following:

Unit Operations	30%
Unit Processes	6%
Industrial Technology	31%
Unclassified	33%

This summary is for forty-three schools with good geographic distribution, though almost half of the titles were from five schools. The distribution of the 191 titles in the first three classifications follows:

Unit Operations		*Unit Processes*		*Industrial Technology*	
Heat transfer	21	Hydrolysis	3	Metals	24
Distillation	16	Nitration	2	Petroleum	16
Absorption	11	Halogenation	1	Paint	12
Fluid flow	6	Thermal decomposition	1	Electrochemistry	10
Drying	5	Ammonalysis	1	Synthetics	5
Extraction	5	Sulfonation	1	Plastics	5
Diffusion	5	Dialysis	1	Spectroscopy	3
Condensation	5	Hydrogenation	1	Food	3
Evaporation	3	Reduction	1	Rayon	3
Adsorption	3	Amination	1	Colloids	2
Crystallization	2	Hydration	1	Fermentation	1
Filtration	2	Esterification	1	Ceramics	1
Mixing	2	Dissociation	1	Rubber	1
Humidification	1	Alhylation	1	Glass	1
Size-separation	1		—	Refrigeration	1
Size-reduction	1		17	Water	2
	—			Paper	1
	89				—
					91

Unclassified—94 titles.

Experimental work in the unit operations shows about 53 per cent was carried on in heat transfer, distillation, and absorption with another 32 per cent in fluid flow, drying, extraction, evaporation and condensation. The unit processes showed very little definite trend with 14 separate titles in 17 different processes. In the field of Industrial Technology, 17 different sub-classifications were

found with about 68 per cent in the fields of metals, petroleum and electrochemistry. Unclassified included 94 titles—the term is fairly descriptive. The subject material relates to local economies and industry, physical measurements, methods of control, analysis, conditions of operation and in general material not classified before.

Civil Engineering.—A review of the thesis titles and subjects related to civil engineering shows a wide diversification of research, both as regards subject matter and type of investigation. A total of 287 thesis titles related to civil engineering were involved in this review. Of this number 17 were doctor's theses.

Approximately one-third of the total number concerned studies, both experimental and analytical, in the theory of elasticity in structures; one-quarter dealt with studies of hydraulics and hydrology, while the remainder included such studies as soil mechanics, water supply and sanitary engineering, highways and transportation, and other miscellaneous subjects. The following percentage distribution of titles is indicative of the general coverage. The percentages are subject to considerable variation because even in the title listing there are many borderline cases.

Structures	37%
Hydraulics and Hydrology	27%
Water Supply and Sanitary Engineering	9%
Soil Mechanics	8%
Highway Engineering and Transportation	6%
Miscellaneous	13%

In structures problems the investigations of the methods of analysis of statically indeterminate frames is a major classification of the titles, although the analysis of concrete structures and experimental study of concrete properties is included. Photoelastic analysis and the discussion of actual designs are also among the titles. Under hydraulics and hydrology are included many experimental theses. These involve varied flow in open channels, wave propagation, laminar and turbulent flow studies, and the like. River problems and atmospheric disturbances form other classifications under this group.

Although the research as indicated by thesis titles is quite broad in scope when the entire group of universities within the United States is considered, there seem to be definite tendencies toward grouping of subject matter at individual institutions. This would seem to be a desirable situation and doubtless permits specialization and a higher standard of research. It of course does not follow any planned scheme but rather is influenced largely by the chance distribution of competent personnel and facilities at the various institutions.

Electrical Engineering.—Forty-seven schools supplied information on a total of 192 graduate thesis titles. Of this number only six were submitted in partial fulfillment for the doctor's degree. The list of thesis titles in electrical engineering was subdivided roughly as follows: applied mathematics and physics, one-sixth of the total; power, almost one-half; and communications, one-third. Roughly, two-thirds of the total number of thesis titles were submitted by schools in the northern section of the United States east of the Mississippi River. Details of the distribution of titles—again subject to uncertainty in borderline cases—is as follows:

Applied mathematics	3%
Applied physics	13%
Electrical power (including power plants, transmission machines, high voltage materials and measurements, circuits and instruments)	45%
Electric communications	35%
Illumination	1%
Economics	3%

With the exception of the fields of applied mathematics and economics, practically all the theses were combinations of experimental and theoretical work. It is noteworthy, too, that the specific interests and capabilities of the graduate faculty members, responsible for the supervision of research, is clearly reflected in the grouping of thesis titles according to institutions.

Mechanical Engineering.—An examination of the titles of theses submitted in 1939 for advanced degrees in mechanical engineering indicates that about 60 per cent of the 206 theses from the 44 institutions reporting were concerned with experimental projects. Of the total number only 12 were doctor's theses.

Subjects dealing with heat and power accounted for almost one-half of all titles. About one-third of these power subjects dealt with internal combustion engines and another one-third with heat transfer. Of the 206 subjects, 22 were in the field of fluid mechanics and 13 in aeronautics, making about 17 per cent for these two subjects. There were 30 theses on subjects in applied mechanics and 20 more on materials and materials testing. The entire field of industrial and shop management including all phases of economics and business was represented by only 19 thesis titles.

Immediate practical application of the results was apparently contemplated in more than half the studies. Problems which would call for rigorous analytical treatment were probably 20 per cent of the total.

Geographically the largest group of thesis subjects was reported from institutions in the northeastern United States, about one-half

being reported from schools east of Ohio. However, eight of the 12 doctor's degrees were conferred by institutions in California.

Classified according to subject matter, the distribution of titles was about as follows:

Heat and power	47%
Mechanics, materials and design	29%
Fluid mechanics and aeronautics	17%
Industrial and economics subjects	7%

Classified as to function or type of work, about 59 per cent of the total theses were experimental, 21 per cent analytical, 9 per cent design, and 11 per cent unclassified.

Engineering Mechanics and Mathematics.—This subdivision of thesis titles overlaps virtually all other subdivisions and while only 35 titles are reported from 14 schools, many border line titles are listed under civil, electrical, chemical, mechanical, and mining engineering subdivisions. Eight doctor's theses are included in the group.

The 35 titles are subdivided roughly one-sixth in mathematics, one-third in mechanics, and one-half in materials. Titles covering photoelasticity, stress analysis, and fluid mechanics, are also listed under civil engineering and mechanical engineering theses. Titles bearing on the properties and behavior of materials pertain to ferrous materials chiefly, with aluminum, plastics, and concrete in secondary positions. Here again are numerous borderline cases of theses which have been classified under civil and mechanical engineering respectively. It seems appropriate here to consider indications of trends in engineering mechanics and mathematics rather than a mere statistical analysis of thesis titles.

The trend in applied mathematics seems to be toward a more extensive use of matrices and tensor analysis in problems of electrical networks and of rotating machinery. The compactness and simplification made possible by this new theory is helping to advance knowledge in electrical theory and practice quite materially. In the radio communications field new uses are being found for Bessel's functions. In fact Bessel's functions of higher order than those for which tables have been computed are needed. In physics the theory of probability and its application to the modern quantum and molecular theories is being pushed. Integral equations as opposed to differential equations seem to be giving satisfactory results in certain problems. Some of the newer geometries are being used to interpret physical knowledge. Lastly, the theory of transformations and a knowledge of the invariants under a given transformation are playing an increasingly important part in the advanced problems of engineering.

Mineral Industries.—Under this heading have been classified the theses in mining engineering, metallurgy, petroleum and gas engineering, ceramic engineering, and related fields. A total of 130 thesis titles were submitted by 27 schools—18 theses being submitted for doctor's degree. All of the doctor's degrees and nearly two-thirds of the entire number of degrees were conferred by schools in the northern section east of the Mississippi River. The subdivision of thesis titles is proportionately about as follows:

Mining engineering, including geological engineering	22%
Metallurgy	42%
Petroleum and gas engineering	9%
Ceramic engineering	23%
Economics	4%

The metallurgy of ferrous metals and the inspection and working of metals with particular reference to metallurgical problems accounted for half the total number of theses in the metallurgy subgroup.

Summary of Tallies.—A total of 1141 thesis titles are listed in the appendix. The schools which in the aggregate reported half of the total number are: Massachusetts Institute of Technology (241), Ohio State University (54), University of California (53), Columbia University (48), Cornell University (42), University of Illinois (38), Case School of Applied Science (30), Stanford University (29), and University of Texas (15).

Chemical Engineering. Total, 291 titles, one-half of which was reported by: Massachusetts Institute of Technology (68), Ohio State University (29), Columbia University (16), Lehigh University (16), University of Texas (15).

Civil Engineering. Total 287 titles, one-half of which were reported by: Massachusetts Institute of Technology (50), Cornell University (28), University of California (19), University of Colorado (17), University of Illinois (13), Rensselaer Polytechnic Institute (11), and University of Iowa and University of Michigan (10 each).

Electrical Engineering. Total, 192 titles, one-half of which were reported by: Massachusetts Institute of Technology (46), Columbia University (12), Stanford University (12), University of California (11), Ohio State University (9), University of Illinois (8).

Mechanical Engineering. Total, 206 titles, one-half of which were reported by: Massachusetts Institute of Technology (48), University of California (23), Purdue University (10), Armour Institute of Technology and the University of Pittsburgh (7 each),

California Institute of Technology, Case School of Applied Science, Columbia University, and Cornell University (6 each).

Engineering Mechanics and Mathematics. Total, 35 titles, exclusive of titles in related fields which had been reported in the other major divisions of thesis classifications. Massachusetts Institute of Technology reported 12, and the University of Illinois 6, to account for half the total number.

Mineral Industries. Total, 130 titles, one-half of which were reported by: Massachusetts Institute of Technology (17), University of Illinois and Montana School of Mines (10 each), Ohio State University (9), Pennsylvania State College (8), Columbia University and Lehigh University (7 each).

In submitting this report the committee desires to emphasize that undue weight should not be given to and unjustified inferences should not be drawn from the statistical summaries nor from the list of thesis titles. The committee wishes to stress its belief

(1) That this list of unpublished researches may be helpful in locating potential research workers and research facilities in relation to national defense, and

(2) That to each individual supervisor of graduate student research the list of titles may serve as a kind of yardstick of accomplishment and as a stimulus to improvement in some phases of graduate work in engineering.

Acknowledgments.—The Committee is grateful to the deans, department heads, and their secretaries who assembled the lists of thesis titles in their respective schools. The Committee wishes to thank the following persons especially for counsel and assistance in analyzing and classifying the data in this report: C. A. McKeeman (Case), H. A. Curtis (Missouri), R. N. Shreve (Purdue), F. C. Vilbrandt (Virginia Polytechnic), R. C. Kintner (Armour), W. L. McCabe (Carnegie), A. P. Colburn (Delaware), and O. A. Hougen (Wisconsin).

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APPENDIX 1. STATISTICAL SUMMARY OF GRADUATE ENGINEERING THESES SUBMITTED IN 1939.

School	Ch.E.	C.E.	E.E.	M.E.	Math. and Mech.	Min. and Related	Total
Alabama Polytechnic Institute	1	1	2	2	—	—	6
Alabama, University of	—	2	—	—	—	5	7
Armour Institute of Technology	5	2	1	7	—	—	15
Brooklyn Polytechnic Institute	7	—	3	3	1	—	14
California Institute of Technology	—	1	1	6	—	—	8
California, University of	—	19	11	23	—	—	53
Carnegie Institute of Technology	7	1	1	—	1	—	10
Case School of Applied Science	14	1	1	6	3	5	30
Catholic University of America	—	1	—	—	—	—	1
Colorado School of Mines	—	—	—	—	—	4	4
Colorado, University of	1	17	3	—	—	—	21
Columbia University	16	7	12	6	—	7	48
Cornell University	3	28	3	6	2	—	42
Georgia School of Technology	2	1	—	3	—	—	6
Harvard University	—	5	1	—	—	2	8
Idaho, University of	—	2	—	1	—	6	9
Illinois, University of	—	13	8	1	6	10	38
Iowa State College	4	7	2	4	2	—	19
Iowa, University of	6	10	1	3	—	—	20
Johns Hopkins University	—	—	2	—	—	—	2
Kansas State College	1	—	3	4	1	—	9
Kansas, University of	—	—	1	—	—	1	2
Kentucky, University of	—	1	2	3	—	—	6
Lehigh University	16	1	2	3	—	7	29
Louisiana State University	3	4	1	2	—	—	10
Louisville, University of	4	—	—	—	—	—	4
Maine, University of	2	—	1	—	—	—	3
Massachusetts Institute of Technology	68	50	46	48	12	17	241
McGill University	2	1	—	—	—	2	5
Michigan State College	4	1	—	1	—	—	6
Michigan, University of	4	10	1	—	—	4	19
Minnesota, University of	2	8	3	4	1	3	21
Mississippi State College	—	1	—	—	—	—	1
Missouri School of Mines	—	2	—	—	—	—	2
Missouri, University of	—	—	2	—	—	—	2
Montana School of Mines	—	—	—	—	—	10	10
Montana State College	—	1	—	1	—	—	2

APPENDIX 1.—*Continued.*

School	Ch.E.	C.E.	E.E.	M.E.	Math. and Mech.	Min. and Related	Total
Nebraska, University of	—	3	1	2	—	—	6
New Hampshire, University of	—	1	—	1	—	—	2
New York University	3	7	—	5	—	—	15
North Carolina State College	7	3	1	1	—	2	14
North Dakota, University of	2	2	1	—	—	—	5
Notre Dame, University of	—	—	—	—	—	1	1
Ohio University	—	—	2	—	—	—	2
Ohio State University	29	3	9	3	1	9	54
Oklahoma A. & M. College	4	—	—	—	—	—	4
Oklahoma, University of	3	—	—	—	1	—	4
Oregon State College	—	—	3	1	—	—	4
Pennsylvania State College	4	3	1	1	2	8	19
Pennsylvania, University of	—	—	6	—	—	—	6
Pittsburgh, University	2	6	4	7	1	—	20
Princeton University	6	2	3	3	—	—	14
Purdue University	4	5	7	10	—	2	28
Rensselaer Polytechnic Institute	2	11	—	5	—	1	19
Rochester, University of	1	—	—	1	—	—	2
South Dakota School of Mines	2	4	—	—	—	—	6
Southern California, University of	1	3	—	—	—	4	8
Stanford University	1	4	12	5	1	6	29
Stevens Institute of Technology	1	1	—	2	—	—	4
Syracuse University	—	1	1	—	—	—	2
Tennessee, University of	5	3	2	1	—	—	11
Texas, A. & M. College of	2	7	2	3	—	—	14
Texas Technological College	2	—	—	—	—	—	2
Texas, University of	15	2	5	5	—	2	29
Tulane University of Louisiana	—	4	1	1	—	—	6
Utah State Agricultural College	—	1	—	—	—	—	1
Utah, University of	—	—	—	1	—	5	6
Virginia Polytechnic Institute	12	5	6	4	—	1	28
Washington State College	—	1	—	—	—	—	1
West Virginia University	3	1	2	—	—	—	6
Wisconsin, University of	6	5	2	4	—	3	20
Worcester Polytechnic Institute	—	—	4	2	—	—	6
Yale University	2	1	3	1	—	3	10
	291	287	192	206	35	130	1141

APPENDIX 2. TITLES OF GRADUATE ENGINEERING THESES SUBMITTED IN AMERICAN SCHOOLS IN 1939

Theses 1938–39: Chemical Engineering

Alabama Polytechnic Institute

The use of sweet potato starch in the preparation of phenolformaldehyde resins, Charles Smith Chisholm, M.Ch.E., May 1939.

Armour Institute of Technology

Catalytic aromatization of straight-run gasoline, Charles H. Riesz, Ph.D. in Ch.E., June 1939.

Packed columns in vacuum distillation, Edward Charles Berger, M.S. in Ch.E., June 1939.

Equilibrium and distillation studies (new Binary mixtures), Robert Michael Levy, M.S. in Ch.E., June 1939.

Design, construction and operation of a humidifier-gas absorber, Robert Mathias Lundberg, M.S. in Ch.E., June 1939.

Cyclodehydration of normal octyl alcohol, George Thodos, M.S. in Ch.E., June 1939.

Polytechnic Institute of Brooklyn

The chemical constitution of an ether insoluble fraction of shellac, Julian Filfus, Ph.D. (Chem.), June 1939.

Shellolic acid and some allied acids of shellac, Philip Moore Kirk, Ph.D. (Chem.), June 1939.

Investigation of a method for the manufacture of stearyl peroxide, Herbert W. Beck, M.Ch.E., June 1939.

The use of the organic peroxides in refining vegetable oils, John F. Gerkens, M.Ch.E., June 1939.

The production of anhydrous, crystalline caustic soda by a partial pressure evaporation process, Joseph J. Jacobs, Jr., M.Ch.E., June 1939.

The synthesis of thidioglycol, Donald Q. Kern, M.Ch.E., June 1939.

Separation and purification of reaction products when fusing sawdust with caustic soda in the production of exalic acid, and the design of a plant with cost analysis and estimates, Robert H. Royer, M.Ch.E., June 1939.

Carnegie Institute of Technology

A dilatometric study of the kinetics of precipitation from the solid solution of silicon in aluminum, Lawrence K. Jetter, D.Sc., June 1939.

The heat capacities of titanium oxide, 1, 2, and of iron carbide from 68–298° K, Hugh J. McDonald, D.Sc., June 1939.

Infrared investigation of dilute solutions of HCl and H Br, John Allyn Ord, D. Sc., June 1939.

Flow of gases at high pressures with large pressure drops, Robert F. Freeman, M.S. in Ch.E., and Donald Sener, June 1939.

Studies in packed tower distillation, John E. Swearingen, Jr., M.S. in Ch.E., June 1939.

The effect of insoluble particles on crystallization, John Girt Wehn, M.S. in Ch.E., June 1939.

Heat transfer coefficients in annular spaces, Richard K. Britton, M.S. in Ch.E., and William Franz, June 1939.

Case School of Applied Science

Derivatives of unsymmetrical diphenylethane, Fred Easly Sheibley, Ph.D., June 1939.

High temperature greases, Walter Karl Asbeck, M.S. in Ch.E., June 1939.

Butadiene from hydrocarbons, Andrew Evert Chute, M.S. in Ch.E., June 1939.

Design and installation of a pilot plant distillation and absorption unit, Harry Nelson Cotabish, M.S. in Ch.E., June 1939.

Study of sulfonation by dioxane sulfotrioxide, William Irwin Denton, M.S. in Ch.E., June 1939.

The relation of the carbon-oxygen linkage to anaesthetic potency in some analogs of anaesthesine, Paul Victor Kunz, M.S. in Ch.E., June 1939.

Derivatives of diisobutylphenol, G. Herbert Metzger, M.S. in Ch.E., June 1939.

Catalytic cyclization of butylene, William Herman Schuette, M.S. in Ch.E., June 1939.

Butadiene from hydrocarbons, Paul Robert Schults, Jr., M.S. in Ch.E., June 1939.

A study of pigment dispersion in paint vehicles, George Selden, M.S. in Ch.E., June 1939.

Study of hydrates of ferric oxide, E. Jackson Thomas, Jr., M.S. in Ch.E., June 1939.

Analysis of hydrocarbon mixtures by A. S. T. M. distillation, Richard Raymond Thompson, M.S. in Ch.E., June 1939.

P-amino phenyl ethers and their anaesthetic action, Herbert Frederick Wiese, M.S. in Ch.E., June 1939.

A study of drying rates of granular materials, Fritz Manthey Zorn, M.S. in Ch.E., June 1939.

University of Colorado

A control method for recovery of epsom salts by solar evaporation, Walter Milton Carlson, M.S. in Ch.E., August 1939.

Columbia University

Beneficiating ferruginous bauxites through clorination, Vincenzo Salvatore de Marchi, Ph.D., 1938–39. (Ch.E.)

The problems of compressed and heat-treated copper powders, Claus Guenter Goetzel, Ph.D., 1938–39. (Met.)

Performance of ejectors as a function of the molecular heats of vapors, Vincent William Haedrich, Ph.D., 1938–39. (Ch.E.)

Refractive index and viscosity measurement of tetarium sulphate solution, Joseph Daniel Stetkewicz, Ph.D., 1938–39. (Ch.E.)

Production of Beryllium oxide, Ernest Albert Winter, Ph.D., 1938–39. (Ch.E.)

Electrometallurgy of Molybdenum, Henry Stanley Myers, M.S., 1938–39. (Ch.E.)

Corrosion resistance of copper coated steel, Edgar Ewart Wrege, M.S., 1938–39. (Ch.E.)

Electrolytic oxidation of cyclohexanone, John Burggraf Bockelmann, Engineering Degree 1938–39. (Ch.E.)

Leaching of chromium from chromite ore, Harris Aubrey Clay, Engineering Degree 1938–39. (Ch.E.)

Wetting properties of bodied oils (Fish, Tung, Oiticica), Lawrence Gussman, Engineering Degree 1938–39. (Ch.E.)

Hydrotropic solvent for sulfur dioxide, Murry Leo Hurwitz, Engineering Degree 1938–39. (Ch.E.)

Electrolytic oxidation of benzene to quinone, Joseph Koslov, Engineering Degree 1938–39. (Ch.E.)

Solvent refining of vegetable oils, Henry Peter Ozimek, Engineering Degree 1938–39. (Ch.E.)

Separation of fatty acids by hydrotropic solvents, Thomas Beall Richey, Jr., Engineering Degree 1938–39. (Ch.E.)

Producing pure nickel electrolytically, Raymond Clogston Scofield, Engineering Degree 1938–39. (Ch.E.)

Leaching Beryllium ores, Allen Shibley, Engineering Degree 1938–39. (Ch.E.)

Cornell University

Reactions in electric arc welding, Royal David Thomas, Jr., M.Ch.E., February 1939.

Heat transfer to boiling liquids: the role of wettability, George Naumann Cornell, Ph.D., June 1939.

Design of a plant for the manufacture of monochlorobenzene, James Robert Wall, M.Ch.E., June 1939.

Georgia School of Technology

The effect of the degree of polymerization of the cellulose and the draft in spinning on the orientation and the physical properties of the rayon, J. R. Coley, M.S. in Ch.E., June 1939.

The preparation and sulfonation of pinene, P. V. Seydel, M.S. in Ch.E., June 1939.

Iowa State College

Production and utilization of lignin from agricultural by-product materials, Grover Leon Bridger, Ph.D. (Ch.E.), I Summer 1938.

The use of some agricultural products as raw materials in the plastic industry, James Alvin Johnston, Ph.D. (Ch.E.) Fall 1938.

Effect of salt concentrations upon the fermentation of grain mashes, Frank Major Shipman, Ph.D. (Ch.E.) Fall 1938.

Development of a process for the production of sheet material from animal fibers, Robert Emmett Cox, M.S. (Ch.E.) Spring 1939.

University of Iowa

The adsorption of phenol with commercial activated carbons, Frederick Earl England, M.S. in Ch.E., August 1938.

An oxidation index for coal rank, Marion Krouse, M.S. in Ch.E., August 1938.

The inorganic minerals of Iowa coals, Arthur Loren Munson, M.S. in Ch.E., August 1938.

Equilibrium suction water content relationships in porous solids, Lowell Arthur Jobe, M.S. in Ch.E., June 1939.

Capillary flow in porous solids, Franklin Claude Kiesling, M.S. in Ch.E., June 1939.

The cleaning of Iowa coal with the Deister table, Warren Daryl Warinner, M.S. in Ch.E., June 1939.

Kansas State College

Catalytic oxidation of olefins in the vapor phase, Myron Samuel Dendurent, M.S. in Ch.E., July 1939.

Lehigh University

A study of the preparation and properties of index oil, J. V. Fetterman, M.S. in Ch.E., June 1939.

Formaldehyde tannage, W. Priestley, Jr., M.S. in Ch.E., June 1939.

The analysis of linseed oil, N. W. Taylor, M.S. in Ch.E., June 1939.

Analysis of paint decomposition due to weathering, H. A. Ball, M.S. in Chem., June 1939.

Photo-oxidation of phenol, J. T. Bergen, M.S. in Chem., June 1939.

Effect of peroxides on methods of analysis, F. E. Chapman, M.S. in Chem., June 1939.

Bromination of unsaturated compounds with carbon tetrabromide, L. Coblentz, M.S. in Chem., June 1939.

Silicate paints, T. G. Harris, M.S. in Chem., June 1939.

X-ray powder diffraction applied to semi-commercial problems, F. P. Hochgesang, M.S. in Chem., June 1939.

Ester condensation of isobutyl phenoxy acetate with ethyl formate, M. M. Kline, M.S. in Chem., June 1939.

On the catalytic preparation of formaldehyde from carbon monoxide and hydrogen, H. S. Levenson, M.S. in Chem., June 1939.

Reactions of pinene and oleic acid with formaldehyde, J. H. M. Miller, M.S. in Chem., June 1939.

The direct photochemical hydrogen-oxygen reaction, A. Napravnik, M.S. in Chem., June 1939.

Study of rearrangement of dimethyl-ketazine into 3, 5, 5, trimethylpyrazoline, F. G. Smith, M.S. in Chem., October 1939.

Catalytic methods for increasing the unsaturation of long-chain fatty acids, W. C. Forbes, Ph.D. in Chem., June 1939.

High pressure reactions in unsaturated organic compounds, C. A. Heiberger, Ph.D. in Chem., October 1939.

Louisiana State University

The carbonation of lime suspensions, John L. Aitkens, M.S. in Ch.E. (Louisiana State University, Abstracts of Theses, Vol. 31 N.S., No. 1, pp. 44–45, 1939).

The preparation and properties of plastics made from lignin, Thomas C. Landrum, M.S. in Ch.E., (*Ibid.*, Vol. 31 N.S., No. 1, p. 45, 1939).

Study of a terpene resin and its uses in protective coatings, Dalton L. Pollet, M.S. in Ch.E. (*Ibid.*, Vol. 31 N.S., No. 1, pp. 45–46, 1939).

University of Louisville

Factors affecting bronzing of Prussian blue, N. W. Muller, M.Ch.E., 1939.

Correlation of cooling data for kerosene, James Scott, M.Ch.E., 1939.

Modified ethylcellulose exterior house paints, Hugo Schaefer, M.Ch.E., 1939.

Quantitative spectrographic analysis, F. B. Johnston, M.Ch.E., 1939.

University of Maine

An investigation of the influence of composition on individual plate efficiencies in a rectifying column, Hiram LeRoy Smith, Jr., M.S. in Ch.E., June 1939.

Technology, economic balance and design in rayon manufacture and some other industries (starch, nitrocellulose and plastic), Khuat-tat Lin, M.S. in Ch.E., October 1939.

Massachusetts Institute of Technology

Hydration of ethylene by means of dilute mineral acids at high pressure, Adolph Louis Antonio, D.Sc. in Ch.E., Dec. 1939.

Flow relations in liquid and vapor on bubble cap plates, Thonet Charles Dauphine, D.Sc. in Ch.E., Dec. 1939.

The Nitration of Toluene, Ernest Osborne Ohsol, D.Sc. in Ch.E., Dec. 1939.

Correlation of theoretical flame temperature and limits of combustibility of gas mixtures, Randolph Antonsen, M.S. in Ch.E., Dec. 1939.

Molecular distillation of petroleum residua, Charles Richard Bartels, M.S. in Ch.E., Dec. 1939.

Flat plate collectors for house-heating by sunlight, Moses Cammer, M.S. in Ch.E., Dec. 1939.

Surface tension of inorganic salt solutions by pendant drop method, Henry Nicholas Homeyer, Jr., M.S. in Ch.E., Dec. 1939.

Application of colloidal phenomena in the search for better methods of breaking of crude-oil emulsions, Charles Rene Houssiere, Jr., M.S. in Ch.E., Dec. 1939.

Vapor phase esterification, Mark Hyman, Jr., M.S., in Ch.E., Dec. 1939.

Solubility of olefins and diolefins in cuprous salt solutions, Donald Moore Leslie, M.S. in Ch.E., Dec. 1939.

Fused electrolyte mixtures for the electrodeposition of aluminum and some other metals, Arthur Samuel Merrow, Jr., M.S. in Ch.E., Dec. 1939.

Mixed phase nitration of heptane, Eben John O'Brien, M.S. in Ch.E., Dec. 1939.

Effect of velocity on heat transfer to boiling liquids inside pipes, Eugene Oliver, Jr., M.S. in Ch.E., Dec. 1939.

Absorption plate efficiency, George Frederick Schlaudecker (with C. E. Slyngstad), M.S. in Ch.E., Dec. 1939.

Diffusion of hydrocarbon gases through rubber membrane, Lewis Olen White, M.S. in Ch.E., Dec. 1939.

Recovery of phosphorus from phosphate rock, Albert Korman Ackoff, M.S. in Ch.E., June 1939.

Preparation and properties of some organo-bentonite compounds, Leon Baral, M.S. in Ch.E., June 1939.

Liquid mixing by eddy diffusion on bubble cap plates, Abbott Byfield, M.S. in Ch.E., June 1939.

Adsorption of butadiene on cuprous salts, Arthur Henry Christgau, M.S. in Ch.E., June 1939.

Heat transmission by radiation from non-luminous gases. Experimental study of ammonia, Leonard Frank Dowding, M.S. in Ch.E., June 1939.

Study of transfer coefficients in a packed tower, Albert Carl Faatz, Jr., M.S. in Ch.E., June 1939.

Bubble-cap efficiency for desorption in aqueous systems, Horace Walton Fairbrother, Jr., M.S. in Ch.E., June 1939.

Heat transfer to water boiling under pressure, Frederick Bertram Grosselfinger (with T. A. Bjorkman), M.S. in Ch.E., June 1939.

Vapor-liquid equilibria, Earp Franklin Jennings, Jr. (with R. R. Chase), M.S. in Ch.E., June 1939.

Acid adsorption by synthetic resins, Yuen Nong Lee, M.S. in Ch.E., June 1939.

Dissociation of ethyl chloride, Edward Grange Morin, M.S. in Ch.E., June 1939.

Absorption and vaporization in a packed column, Rasiklal Hemchand Parekh (with J. J. Mehta), M.S. in Ch.E., June 1939.

Diffusion of water vapor into various gases in a wetted-wall column, Arthur Carroll Rowley, M.S. in Ch.E., June 1939.

Structure of Bentonite, Walter Geyer Thomas, M.S. in Ch.E., June 1939.

Mechanism of the combustion of fuel oil, Charles Ernest Winters, M.S. in Ch.E., June 1939.

Synthesis of ethylene urea, Floyd Allan Hansen, M.S. in Ch.E., June 1939.

Study of gelation in systems of iron oxide and bentonite, Sidney Hirshon, M.S. in Ch.E., June 1939.

Absorption in wetted-wall columns, James Straton Bruce, M.S. in Ch.E., Dec. 1939.

Heat transfer to boiling benzene, Robert Leon Bryan, M.S. in Ch.E., Dec. 1939.

Flow characteristics of an air-fine particle mixture in vertical tubes, John Michael Chambers, M.S. in Ch.E., Dec. 1939.

Vapor-liquid equilibria, Robert Richard Chase (with E. F. Jennings, Jr.), M.S. in Ch.E., Dec. 1939.

Drying of Wallboard, Robert Wolcott Gaines, M.S. in Ch.E., Dec. 1939.

Effect of pressure on bubble plate efficiency in rectification, Marshall Crapon Guthrie, Jr., M.S. in Ch.E., Dec. 1939.

Preparation and study of aerogels from Bentonite, David Stewart Howard, Jr., M.S. in Ch.E., Dec. 1939.

Recovery of spent sulfuric acid from refinery operations, Charles Cleveland Kind, M.S. in Ch.E., Dec. 1939.

Heat transfer for partial condensation of steam and tri-chloroethylene mixtures, Frederick John Kolb, Jr. (with J. R. Weeks, Jr.), M.S. in Ch.E., Dec. 1939.

Diffusion of vapors in a ring packed column, Jayant Jyotendra Mehta (with R. H. Parekh), M.S. in Ch.E., Dec. 1939.

Catalytic cracking of N-Heptane in presence of nickel, Dale Francis Morgan, M.S. in Ch.E., Dec. 1939.

Solubility of ethylene in cuprous salt solutions, Robert Hemingway Park, M.S. in Ch.E., Dec. 1939.

Performance of cooling towers, John Arthur Phinney, M.S. in Ch.E., Dec. 1939.

Effect of wetting agents on the rate of gas absorption, Philip Jackson Rennolds, Jr., M.S. in Ch.E., Dec. 1939.

Organic syntheses in acid media, Marshall Stubbs, M.S. in Ch.E., Dec. 1939.

Pressure drops and loading velocities through packed towers, Paul Tillson, M.S. in Ch.E., Dec. 1939.

Absorption of chlorine in water in a packed tower, Johnson Edward Vivian, M.S. in Ch.E., Dec. 1939.

Chemical structure of vulcanized rubber, John Rowland Brown, Jr., D.Sc. in Ch.E., June 1939.

The mixing of gas and air in flames, William Rede Hawthorne, D.Sc. in Ch.E., May 1939.

Performance of commercial absorption tower packings, Frederic Ancrum Lord Holloway, D.Sc. in Ch.E., June 1939.

The electrochemical fixation of nitrogen, Thomas Henry McConica, III, D.Sc. in Ch.E., May 1939.

Investigation of the alteration of glass to bentonite at high temperatures and pressures, Howard Hecker Reynolds, D.Sc. in Ch.E., June 1939.

Light olefine recovery by cuprous salts, James Edward Seebold, D.Sc. in Ch.E., June 1939.

Mass Transfer by eddy diffusion, Byron Baker Woertz, D.Sc. in Ch.E., June 1939.

Spectrochemical assay for dehydroisoandrosterone and androsterone in synthetic hormone solutions, Abraham Fineman, M.S. in Biol.Eng., June 1939.

Heat transfer to boiling benzene oil mixtures, Donald Joseph Bringardner, M.S. in Ch.E., June 1939.

Determination of the critical moisture content in the drying of clays, Donald Beddoes Broughton, M.S. in Ch.E., June 1939.

Effect of blending anthracite with a coking mixture on the strength of resulting coke, Ming Che Chang, M.S. in Ch.E., June 1939.

Catalytic cracking, Edgar Whitney Clarke, Jr., M.S. in Ch.E., June 1939.

Consideration of vapor jet refrigeration, Maurice Frederick Granville, Jr., M.S. in Ch.E., June 1939.

Heat transfer to boiling liquids under pressure, Arnold Lee Johnson, and Nelson Teague Bogart, M.S. in Ch.E., June 1939.

Corrosion of nitrogen-free 18–8 stainless steel-effect carbon, Harry Edgar Trout, Jr., M.S. in Ch.E., June 1939.

Solvent extraction in a perforated plate column, Richard Norman Wimpress, M.S. in Ch.E., June 1939.

Synthesis of acetic acid from methyl alcohol and carbon monoxide, Chih Wu, M.S. in Ch.E., Dec. 1939.

Influence of ultrasonic waves on the coagulation of colloidal systems, George Greebaum, M.S., Dec. 1939.

Vaporization of benzene from benzene-oil mixtures flowing through a long horizontal tube, Lee Cyril Heroman, Jr., M.S., Dec. 1939.

McGill University

The analysis of classified fractions of certain pulps, E. W. Garner Giddings, M.Eng. (Ch.E.), May 1939.

The recovery of sodium sulphite cooking liquor, Gordon Henry Gribbins, M.Eng. (Ch.E.), May 1939.

Michigan State College

A study of hemlock bark, some reactions of hemlock tannin, Charles E. Aho, M.S. in Ch.E., July 1938.

Equilibrium of carbon in steel in an atmosphere of hydrogen, Frank Wright Littleford, M.S. in Ch.E., March 1939.

I. Combined carbon control in moly-graphitic steel; II. Etched surface conditions of Dowmetal G-alloy during solution and precipitation heat treatments, Denton D. McGrady, M.S. in Ch.E., June 1939.

The beta transformation in brass and the physical structure of pearlite, Raymond E. Schwyn, M.S. in Ch.E., June 1939.

University of Michigan

Density of liquid paraffin hydrocarbons as a function of pressure, temperature, and molecular weight, Fred Kurata, M.S.E., Feb. 1939.

The correlation of equilibrium constants for light hydrocarbons, James H. Schmitt, M.S.E., June 1939.

The pressure, volume, temperature, time, and product-property relations of petroleum during pyrolysis, Robert Lormer Smith, Ph.D., June 1939. (Ch.E.)

The thermal decomposition of wood in the presence of superheated steam at temperatures below 270 degrees centigrade, Robert Walter Merritt, Ph.D., 1939. (Ch.E.)

University of Minnesota

A study on the effect of electrolytic cleaning on the physical and plating properties of steel, Leslie Myron Bernick, M.S. in Ch.E., June 1939.

The influence of surface on the rate of reaction between bauxite and sulfuric acid, Earl Lewis Schulman, M.S. in Ch.E., Aug. 1938.

New York University

A study of problems of lubrication on the Sperry-Cammen adheroscope, Raymond H. Long, M.Ch.E., June 1939.

Experimental investigation of equilibrium attainment in distillation, Rudolph J. Ozol, M.Ch.E., June 1939.

A study of polished metallic surfaces with plane polarized light, Arnold S. Rose, M.Ch.E., June 1939.

North Carolina State College

Mechanical separation and flotation of cassiterite and pegmatite, Robert Perry Harris, M.S., in Ch.E., June 1939.

The value of cerial flours as antitoxidants for cod livers and cod liver oil, Francis Tripp, Ch.E., June 1939.

Conditioning coastal plain waters for domestic and industrial uses, Rupert Leslie Cox, M.Ch.E., June 1939.

A study of the abrasive resistance of electrodeposited nickel, Thomas Eugene Ramsey, M.Ch.E., June 1939.

A study of the surface and underground waters of North Carolina, Ephriam Lee Sawyer, M.Ch.E., June 1939.

The effect of iron in process water on the color of paper, Raymond Worth Stephenson, M.Ch.E., June 1939.

Heat transfer coefficients of a fluid-film unit, Joseph Ernest Yates, M.Ch.E., June 1939.

University of North Dakota

Studies of tars produced by low temperature carbonization of North Dakota lignite, Ber Lev, M.S., 1939.

A study of the activation of lignite under vacuum, Guy Smith McBane, M.S., 1939.

Ohio State University

Mitigation of the industrial pollution of West Virginia streams, Lyle Kermit Herndon, Ph.D. (Ohio State University, Abstracts of Doctoral Dissertations, No. 28, pp. 157–165, 1939.)

The chemical improvement of edible oil color, Ralph Burdellas Vogel, Ph.D. (*Ibid.*, No. 29, pp. 131–138, 1939.)

Heat transfer tests of a glass lined condenser, Leland Frederic Roy, Ph.D. (*Ibid.*, No. 29, pp. 221–226, 1939.)

The effect of copper in milk on the corrosion of nickel in that fluid, Charles Albert Rohrman, Ph.D. (*Ibid.*, No. 30, pp. 147–154, 1939.)

The rate of oxidation of tung oil, William Craig Orr White, Ph.D. (*Ibid.*, No. 30, pp. 237–245, 1939.)

H.T.U. (height of transfer unit) and transfer coefficients, packed column still, Daniel Webster Duncan, M.S. (Ohio State University, Abstracts of Masters' Theses, No. 28, pp. 82–83, 1939.)

The mechanism of crystallization in the triple effect salting-out evaporator, Harvey Howard Grice, M.S. (*Ibid.*, No. 28, p. 120, 1939.)

Phenolic plastics, Elton Brandon Gunyou, M.S. (*Ibid.*, No. 28, p. 122, 1939.)

Measurement of admixture effects upon the viscosity of nitrocellulose solutions, Paul Hamilton Lenz, M.S. (*Ibid.*, No. 28, pp. 179–180, 1939.)

Latent heats of vaporization of high boiling organic liquids, Donald Edwin Powell, M.S. (*Ibid.*, No. 28, pp. 236–237, 1939.)

Chlorination—chemical engineering design and operation constants, Harold Wright Quigley, M.S. (*Ibid.*, No. 28, p. 241, 1939.)

The thermal decomposition of carbon monoxide, William Cassel Shank, M.S. (*Ibid.*, No. 28, pp. 272–273, 1939.)

Mechanical strength of glues and adhesives, Robert Franklin Snider, M.S. (*Ibid.*, No. 28, pp. 288–289, 1939.)

Foam theory and chemical industry, John Edward Teagarden, M.S. (*Ibid.*, No. 28, pp. 314–315, 1939.)

The measurement of the disintegration of refractory brick, Edward Joseph Haven, M.S. (*Ibid.*, No. 29, p. 27, 1939.)

The effect of the thermal conductivity of liquids on heat transfer coefficients of a glass-lined condenser, John Tudor Wilson, Jr., M.S. (*Ibid.*, No. 29, pp. 67–68, 1939.)

Synthetic plastics available for paints and varnishes, Allen I. Gordon, M.S. (*Ibid.*, No. 29, p. 84, 1939.)

Dialysis efficiency in the recovery of yellow caustic soda from viscose rayon process, Gerhard Frank Lamers, M.S. (*Ibid.*, No. 29, pp. 93–94, 1939.)

The behavior of calcium and magnesium oxides and hydroxides with organic chemicals, Richard Francis McCormick, M.S. (*Ibid.*, No. 29, pp. 103–104, 1939.)

Thermal reduction of alumina and magnesia, Raymond James Anderson, M.S. (*Ibid.*, No. 30, pp. 4–5, 1939.)

Factors affecting rate, efficiency, and constants of washing in filter presses, Robert Wayne Conaway, M.S. (*Ibid.*, No. 30, p. 23, 1939.)

The vapor phase ammonolysis of alcohols, Frederick Eastman, M.S. (*Ibid.*, No. 30, p. 26, 1939.)

Hydrolysis-engineering design and operation constants, Alexander Newhouse, M.S. (*Ibid.*, No. 30, pp. 80–81, 1939.)

Sulfonation—chemical engineering design and operation constants, Robert Sidney Radow, M.S. (*Ibid.*, No. 30, pp. 91–92, 1939.)

Factors affecting filtration constants, Randal Eugene Smith, M.S. (*Ibid.*, No. 30, pp. 112–113, 1939.)

The adhesive properties of plastics and their improvement, Paul Laurence Suter, M.S. (*Ibid.*, No. 30, pp. 117–118, 1939.)

Vapor-liquid composition relationships of a batch column still, George Schambs Tobias, M.S. (*Ibid.*, No. 30, pp. 122–123, 1939.)

The hydrogenation of di-chloro-pentane to mono-chloro-pentane, Harry Bernard Warner, M.S. (*Ibid.*, No. 30, p. 125, 1939.)

Concentration gradient and dimensionless number correlation in dialysis, Burton Meyer Wolf, M.S. (*Ibid.*, No. 30, pp. 136–137, 1939.)

Oklahoma A. & M. College

Design of lime burning plant, Woodrow Wilson Chew, M.S. in Ch.E., July 1938.

The effect of leaching time, at the optimum acid concentration, on the rejuvenation of spent bleaching clay, Lawrence Hein, M.S. in Ch.E., July 1938.

Heat transfer, coefficients for oil to oil heat exchanges, Henry Ireton, M.S. in Ch.E., May 1939.

Morpholine as a selective solvent for refining lubrication oil, Owen F. Thornton, M.S. in Ch.E., May 1939.

University of Oklahoma

Flow of heat through porous media, William Dean Harbert, June 1939.

Heat transfer to boiling liquids, Edward S. Homan, June 1939.

An investigation of freezing of natural gas regulators, II, June 1939.

Pennsylvania State College

A study of the six carbon atom hydrocarbons in natural naphthas from Bradford, Pennsylvania, and Smithfield, West Virginia, Stephen Lawroski, M.S. in Ch.E., 1939.

A preliminary investigation of the characteristics of a packed column for the absorption of carbon dioxide in a solution of di-ethanolamine, James O'Hara Maloney, M.S. in Ch.E., 1939.

Hydrogenation studies and the preparation of cyclopentane, Holman Gordon Miller, M.S. in Ch.E., 1939.

A study of the eight and nine carbon atom hydrocarbons in straight run Pennsylvania naphtha, Albert Eugene Schubert, M.S. in Ch.E., 1939.

University of Pittsburgh

Preparation of meta-nitro-para-toluidine, Lawrence J. Ertle, M.S., June 1938.

The electrolytic reduction of para-nitro-toluene to para-azo-toluene, Richard F. Scheideman, M.S., August 1938.

Princeton University

An attempt to isomarize ortho nitrotoluene to para nitrotoluene, H. P. Brokaw (Ch.E.)

The catalytic amination of ethylene, W. K. Coors (Ch.E.).
Liquid liquid extraction from single drops, J. V. Hardy (Ch.E.).
Correlation of rotameter flow rates, Part II, H. A. Hott (Ch.E.).
Methods of separation of organic isomers by solvent extraction, D. Pratt (Ch.E.).
Solvent extraction in the refining of glycerol, D. S. Plumb (Ch.E.)

Purdue University

1. Metals suitable for pyridyl mercuration equipment.
2. Mercuration of pyridine sulfonic acid with mercuric acetate, James Hugh Cronk, M.S. in Eng., Jan. 1939.

Use of organic solvents in causticizing, Glen Floyd Roquemore, M.S. in Eng., June 1939.
The recovery of glycerol from distillery slops, Dexter Alanson Smith, M.S. in Eng., June 1939.
The determination of the factors affecting the commercial production of barium chloride and calcium chloride, Richard Kenneth Toner, Ph.D., June 1939.

Rensselaer Polytechnic Institute

The determination of film coefficients for the system: Methanol-water condensing differentially inside a vertical cylinder, Richard Harry Fink, M.Ch.E., June 1939.
The determination of film coefficients for the system: Methanol-water condensing differentially outside a horizontal pipe, Robert Parke Lukens, M.Ch.E., June 1939.

University of Rochester

Fluid flow as a limiting factor in fractionating column capacity, Ralph Edwin Pike, M.S. in Ch.E., June 1939.

South Dakota School of Mines

An investigation of bentonite and related materials, James Kenneth Gould, M.S. in Ch.E., June 1939.
Industrial suitability of bentonite and sub-bentonites, Clifton Paul Wilcox, M.S. in Ch.E., June 1939.

University of Southern California

The extraction of strontium salts from impure strontium ores, Lee Joseph Strobl, M.S. in Ch.E., June 1939.

Stanford University

The development of apparatus for measuring heat capacities of vapors, Milo George Kiperash, Engr. (Eng. Chem.), June 1939.

Stevens Institute of Technology

Phenol formaldehyde resins, Mathew H. Bilyk, M.S., June 1939.

University of Tennessee

A pilot plant study of the packer-tower collection of the higher phosphoric acids, Ward H. Sacks, Jr., M.S., June 1939.
A technical and economic study of the production of dicalcium phosphate from triplesuperphosphate, John Craigmiles Davis, M.S., August 1939.
The effective heating surface in a basket type evaporator, Mansell E. Ramsey, M.S., August 1939.
The effect of physical factors on the fluidity of sulfuric acid-phosphate rock mixtures, Ziv Rushansky, M.S., August 1939.

The development of a continuous centrifugal-type superphosphate mixer, Robert Lee Parrish, M.S., August 1939.

A. and M. College of Texas

A study of the condensation of primary, secondary, and tertiary butyl alcohols with benzene in the presence of anhydrous ferric chloride, Ralph Jordan Dodson, M.S. in Ch.E., June 1939.

Fractional distillation of natural gasoline by means of a modified Podbielniak apparatus, Alfred John Lawrence Toombs, M.S. in Ch.E., August 1939.

Texas Technological College

Atlas of arc and Geissler tube spectra of seventy-four of the elements, H. H. Hurmence, M.S. in Ch.E., 1938.

Analysis of cotton burrs, William Richards, M.S. in Ch.E., 1939.

University of Texas

A study of the electric discharge in methane; XIII: The use of a rotating cathode in the synthesis of acetylene by electric discharge, Lindsay Ira Griffin, Ph.D., June 1939.

A study of the electric discharge in methane; X: (*a*) experimental: development of iron discharge chambers and of the multiple-point discharge; (*b*) theoretical: energy relations, Ernest Henry Koepf, Ph.D., June 1939.

A study of the electric discharge in methane; XII: The effect of a series of multiple electrode discharges on methane and methane-hydrogen sulfide mixtures, Conrad Henry Kollenberg, Ph.D., June 1939.

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A study of the electric discharge in methane; XIV: The electric discharge in methane at atmospheric pressure with rotating cathode, Charles Thomas Wells, Jr., Ph.D., June 1939.

Limiting corroding concentrations of anions in the corrosion of iron, Vesta Fletcher Michael, M.S. in Ch.E., June 1939.

Hydrogen content as a basis for correlation of heat capacity of liquid hydrocarbon mixtures, Howard Albert Alves, M.S. in Ch.E., August 1939.

Liquid-Vapor equilibrium of the system water-aniline from the water phase, Earl Franklin Arnett, M.S. in Ch.E., Aug. 1939.

The heat of solution of gaseous monoethylamine, Margaret Roberta Brown, M.S. in Ch.E., August 1939.

The electrical conductivity of monomethylamine solutions at 18° and 25° centigrade, John Franklin Draffen, M.S. in Ch.E., Aug. 1939.

The solubility of acetylene in two petroleum fractions and in cyclohexane, Henry Alvin Holcomb, M.S. in Ch.E., Aug. 1939.

The solubility of water in hydrocarbons at elevated temperatures and pressures, John Edward Kasch, M.S. in Ch.E., Aug. 1939.

P-V-T relations of solutions of gases in liquids at high pressures: Construction and calibration of apparatus; the methane-benzene system at 100° F, Archie Stanley Kasperik, M.S. in Ch.E., Aug. 1939.

The catalytic alkylation of acetylene with methane, Ira Harvey Oliver, M.S. in Ch.E., Aug. 1939.

The production of highly adsorptive activated charcoals from Texas woods, Edward Garrison Spinks, Jr., M.S. in Ch.E., Aug. 1939.

Virginia Polytechnic Institute

Insulating board from whole cotton plant, Herbert Templeton Bates, M.S. in Ch.E., 1939.

Hydrolysis of peanut hulls with a strong acid and alkali, Robert Stanley Dicks, Jr., M.S. in Ch.E., 1939.

Heat transfer in heating and cooling of viscous liquids, Benjamin Thompson Graham, Jr., M.S. in Ch.E., 1939.

Size-reduction characteristics of an experimental swing hammermill, James Walter Kesterson, M.S. in Ch.E., 1939.

The hydrolysis of peanut hulls with dilute acid alkali, Charles Beckman Mather, M.S. in Ch.E., 1939.

Heat transfer coefficients between condensing organic vapors and a vertical copper tube, Robert Hall Morrison, Jr., M.S. in Ch.E., 1939.

The effect of various filtering media on oil oxidation and bearing metal corrosion, Arthur William Olschefski, M.S. in Ch.E., 1939.

The design, construction, and operation of a continuous screw conveyor type mixer and crystallizer, Luther Clayman Peery, M.S. in Ch.E., 1939.

Efficiency factors in a new multi-pipe fractionating plate, Walter Jean Peters, M.S. in Ch.E., 1939.

Corrosion of alloys by crude fatty acids at high temperatures, George Jacob Schaaf, M.S. in Ch.E., 1939.

The drying and curing of yellow leaf tobacco by air conditioning methods, Henry Brower Smith, M.S. in Ch.E., 1939.

Comparative investigation of copper knit-metal cloth and Raschig rings as absorption tower packings, William Owen Switzer, M.S. in Ch.E., 1939.

West Virginia University

Electrolytic purification of water, James Chapman Goodwin, M.S. in Ch.E., September 1939.

Determination of operating characteristics and costs of a Proctor & Schwartz temperature humidity controlled dryer, Robert M. Schaffner, M.S. in Ch.E., June 1939.

Aliphatic esters of tetrahydrofuroic acid, Sterling Noyes Vines, M.S. in Ch.E., September 1939.

University of Wisconsin

Factors affecting the activity of compounds for the carburization of steel, Mack Sutton, Ph.D., June 1939.

A study of the spheroidization of steel, John Luther Bryan, Jr., M.S. in Ch.E., June 1939.

Condensation of moisture from flue gases of gas fired furnaces, Donald Harvey Gordon, M.S. in Ch.E., June 1939.

Condensation of moisture from flue gases of gas fired furnaces, Herman Frederick Hoerig, M.S. in Ch.E., June 1939.

The absorption of butane in gas oil in a bubble cap tower, Charles Roberts Russell, M.S. in Ch.E., June 1939.

Reclamation of used crankcase oil from automobiles, Raymond Pacausky, M.S. in Ch.E., October 1939.

Yale University

Pressure-volume-temperature relationships of a methane-isopentane mixture, Erwin Hamer Amick, Jr., D.Eng., June 1939.

Vapor phase catalytic reactions of carbon monoxide and ethyl alcohol, Roy Samuelson Arrandale, D.Eng., June 1939.

Civil Engineering

Alabama Polytechnic Institute

The materials, design and manufacture of sub-aqueous asphaltic mixture, Theodore Franklin Yancey, C.E., May 1939.

University of Alabama

The design of a typical structure on a proposed parkway for Tuscaloosa, Alabama, James Farr Beeson, M.S. in C.E., August 1939.

A study of the stilling effect of baffles and resulting head losses, James Manning Faircloth and Howard Hamner Meigs, M.S. in C.E., May 1939.

Armour Institute of Technology

Rate structures for water supply services, George S. Madsen, M.S. in C.E., June 1939.

Secondary stresses in Bascule bridges, George I. Uitti, M.S. in C.E., June 1939.

California Institute of Technology

Some aspects of gully development classification and control, Nephi Albert Christensen, Ph.D. (C.E.), June 1939.

University of California

The effect of curing on volume changes in restrained and unrestrained Portland cement mortar bars, Rupert Ole Alen, M.S. in C.E., May 1939.

Analysis of flood wave data, Paul Hermann Denke, M.S. in C.E.

Transportation of solid-water mixtures in pipe lines, Walter Alexander Faiks, M.S. in C.E.

The development and utilization of groundwater in California, Dan Shlomoh Goldberg, M.S. in Irrigation.

The location and design of an irrigation system on the Fresno River, Alan W. Holliday, M.S. in C.E.

Economic design of Kern River diversion canal, Alvin Kay Yip Joe, M.S. in Irrigation.

A cover study for bombproof structures, Francis James Loomis, M.S. in C.E.

Extension of model study of Cabrillo Beach, Charles Moses McAfee, Jr., M.S. in C.E.

Photoelastic analysis of Hansen Dam, David McCoach, III, M.S. in C.E.

Oscillatory waves, Charles Francis Mitchim, M.S. in C.E.

Three dimensional stress determination by photoelasticity, John Raymond Moore, M.S. in M.E.

Uplift pressures in dams, Gordon Vaughn Richards, M.S. in C.E.

The effect of high pressure during curing period on mortar and concrete, Robert William Russell, M.S. in C.E.

Design of diversion works, Mohamed Ahmed Selim, M.S. in Irrigation, May 1939.

The effect of an explosion on a beam, James W. Sloat, M.S. in C.E.

Equilibrium slopes of sea beaches, Charles Henry Waters, M.S. in C.E.

Tests on fourteen full-sized frame panels to determine the factors which affect strength and rigidity, Edward Marion Browder, Jr., M.S. in C.E., Dec. 1939.

Water plan and irrigation of California, Constantine Panayiotis Christopoulos, M.S. in Irrigation.

Military roads in the World War, John M. Cromelin, M.S. in C.E.

Carnegie Institute of Technology

The effect of drainage on seepage through earth dams, Arthur E. Allen, M.S. in C.E., June 1939.

Case School of Applied Science

Fluid flow net studies by electrical analogy, William Harry McClarran, M.S. in C.E., June 1939.

Catholic University of America

A study of gold mining and mining methods in the Philippine Islands, Lucas P. Paredes, M.C.E., 1939.

University of Colorado

Stiffness and carry-over factors for beams with non-symmetrical straight haunches, August Louis Ahlf, M.S. in C.E., June 1939.

The elimination of voids on formed concrete surfaces, Clayton O'Dell Crane, M.S. in C.E., June 1939.

An analytical and experimental study of energy dissipation and scour prevention at small check drop structures, Haywood Guion Dewey, Jr., M.S. in C.E., June 1939.

Accident occurrence and control on heavy construction of the Bureau of Reclamation, Louis Rea Douglass, M.S. in C.E., June 1939.

Economical size of pipe lines for pumping water, oil, and other fluids, Martin Henry Fresen, M.S. in C.E., June 1939.

Laboratory tests on a reinforced concrete box culvert, John Wedgwood Gordanier, M.S. in C.E., June 1939.

Highway bridge stresses produced by commercial trucks, Carl Allen Hagelin, M.S. in C.E., June 1939.

Distribution of foundation pressures on symmetrically loaded slabs, Howard Drew Larson, M.S. in C.E., June 1939.

An investigation of runoff as a function of precipitation and evaporation on the Trinity River of Texas, Alf Allen Lewis, M.S. in C.E., June 1939.

The theory of concrete creep, William Rudolph Lorman, M.S. in C.E., June 1939.

A new method of design of reinforced concrete members in bending, James Elmer Mandry, M.S. in C.E., June 1939.

Design and testing of the Boulder Dam penstocks, John Parmakian, M.S. in C.E., June 1939.

Engineering contracts and specifications, Frank Charles Tyrrell, M.S. in C.E., June 1939.

Hydraulic experiments of a 1:15 model of the Grand Coulee Dam spillway, Don Carlos Weed, M.S. in C.E., June 1939.

Comparative analysis of building frames under lateral loading, Hal Judson Jennings, M.S. in C.E., August 1939.

A study of low-head siphons, Thomas Glendower Owen, M.S. in C.E., August 1939.

A study for the design of crests for overfall dams, Jacob Eugene Warnock, M.S. in C.E., August 1939.

Columbia University

Ten connected plate lengths, Bruce Gilbert Johnston, Ph.D., 1938–39. (C.E.)

A critical study of engineering education in the United States, Abraham Calmus, M.S. (C.E.) 1938–39.

Stress distribution around a loaded pile, James Ruderman, M.S. (C.E.) 1938–39.

The broad crested weir, William Proctor Cartwright, M.S. (C.E.) 1938–39.

Effect of position of reinforcement and method of placing concrete on bond, Thomas Michael Herbert, M.S. (C.E.) 1938–39.

A simplified tri-axial soil testing apparatus, Sexton Arthur Olin, M.S. (C.E.) 1938–39.

Critical study of soil consolidation tests, Harold Clifton Sperry, M.S. (C.E.) 1938–39.

Cornell University

Design of a rolled earth dam: stability of slopes, Oscar Benjamin Beasley, M.S. in Eng., September 1938.

Military bridges of metal, Paul Henry Berkowitz, M.S. in Eng., September 1938.

The relation of permeability tests to subsurface grouting procedure, John Heughes Donoghue, M.S. in Eng., September 1938.

The prevention of reservoir siltation, Robert Erlenkotter, M.S. in Eng., September 1938.

A review of the theory of breakwater construction, with comments on notable breakwater failures, Frederick Benjamin Hall, Jr., M.S. in Eng., September 1938.

The design of earth dams for foundation stability, Aaron Ewan Harris, M.S. in Eng., September 1938.

Investigation of reinforced concrete under combined thrust and bending moment, Clarence Carl Haug, M.S. in Eng., September 1938.

An economic study of short span roof construction, William Joslin Himes, M.S. in Eng., September 1938.

An investigation of combined thrust and bending in reinforced concrete, Stanley Tage Birger Johnson, M.S. in Eng., September 1938.

The design of rolled earth dams: settlement and compaction, Thomas Heber Lipscomb, M.S. in Eng., September 1938.

An investigation of the effect of the depth of the spherical bearing head in compression tests of concrete cylinders, William David Milne, M.S. in Eng., September 1938.

Backwater effects of waterway contractions due to bridge piers and similar encroachments, Donald Abeel Phelan, M.S. in Eng., September 1938.

Design of a rolled earth dam: permeability and seepage section, Chas. Warren Schnabel, M.S. in Eng., September 1938.

A hydraulic study of the birds Point—New Madrid floodway, Ferdinand Julian Tate, M.S. in Eng., September 1938.

A study of rigid frame bridges, Yung-Nien Tsok, M.S. in Eng., September 1938.

The hydraulic effects of bridge pier obstructions to stream flow, Robert Butler Warren, M.S. in Eng., September 1938.

The state of stress in riveted and welded joints as determined by plastic flow observations, John Francis Harvey, M.C.E., September 1938.

Investigation of the methods of determination of the elements of orientation of aerial photographs, Ching-hai Li, M.C.E., September 1938.

Investigation of stress distribution around welded joints, George Francis Strollo, M.C.E., September 1938.

The rigid frame bridge, Tuh-Chung Ting, M.C.E., September 1938.

Adjustment of triangulation of summer survey, 1937 by direction method, Lian-Chia Chao, M.C.E., February 1939.

Study of rigid frame bridge, Chiang Huang, M.C.E., February 1939.

The design of a hydraulic power plant in Fall Creek, Min Jen Pu, M.S. in Eng., June 1939.

Design of a reinforced concrete office building, Chen-yuan Bsu, M.C.E., June 1939.

The economics of highway contracting, Arthur David McGinnis, M.C.E., June 1939.

Reinforced concrete rigid frame building design, Tseng Hsin Ma, M.C.E., June 1939.

Low cost roads, Miguel Joaquin Nolla, M.C.E., June 1939.

A review of the Miami valley flood protection project, Sun You Wong, M.C.E., June 1939.

Georgia School of Technology

The effect of using a blend of Portland Cement and magnolia, slag cement on compressive strength of concrete, J. S. Rimmer, M.S. in C.E., June 1939.

Harvard University

The anaerobic digestion of human excreta, John Raymond Snell, D.Sc., Feb. 1939.

Influence surfaces for stresses in slabs, Francis Martin Baron, D.Sc., June 1939.

Hydraulic elements in design of perforated filter laterals, Warren Every Howland, D.Sc., June 1939.

Influence of anisotropic properties of clay deposits on settlements, Austin Blake Mason, D.Sc., June 1939.

Compression characteristics of clays and application to settlement analyses, Philip Casteen Rutledge, D.Sc., June 1939.

University of Idaho

Terraces for erosion control, Bernardo Secolles Salvador, M.S. in Agr. Eng., 1939.

The effect of altitude on precipitation in the Pacific Northwest, William Benjamin Watson, M.S. in Agr. Eng., 1939.

University of Illinois

A study of the history of specifications for the design of iron and steel bridges prior to 1905, James G. Clark, M.S. (C.E.), June 1939.

Properties of steel continuous frame and stresses in a rigid frame highway bridge, Myron Gossard, M.S. (C.E.), June 1939.

Load Distribution over laminated timber floor slab, Arnold M. Judd, M.S. (C.E.), June 1939.

Comparison of reinforced concrete designs by American and German specifications, Fawzi Kahale, M.S. (C.E.), June 1939.

A study of design based on load at failure, Charles U. Kring, M.S. (C.E.), June 1939.

Economic proportions of steel roof framing, Gwoh-Liang Lee, M.S. (C.E.), June 1939.

The structural behavior of thin cylindrical shells, Emery D. Olson, M.S. (C.E.), June 1939.

Model studies of the hydraulic characteristics of spillways at West Frankfort and Centralia, Ill., Charles O. Reinhardt, M.S. (C.E.), June 1939.

Hydraulic analysis of water distribution systems provided with elevated storage, Kin Seto, M.S. (C.E.), June 1939.

Moments in the simple-span slab and girder bridges, Chester P. Siess, M.S. (C.E.), June 1939.

Strengthening of steel railway bridges, Meng Hsing Tso, M.S. (C.E.), June 1939.

The relative economy of two types of reinforced concrete bridges for a particular case, Oui Thieng Voodhigula, M.S. (C.E.), June 1939.

The stability of railway vehicles on curves, Basil Wrigley Wilson, M.S. (Ry. Eng.), June 1939.

Iowa State College

Measurement of relative humidity with thermocouples, Clifford Gardner Anderson, M.S. (C.E.), Spring 1939.

Factors affecting heat flow through roof sections covered with sheet steel, Norton Conrad Ives, M.S. (Ag.Eng), Winter 1939.

Relative effects of variations in speed, train tonnages, and gradients on steam railway operating expenses, Arthur Maxwell Lees, Jr., M.S. (C.E.), Winter 1939.

The structural requirements of grain storage buildings, Joe Byron Richardson, M.S. (Ag.Eng.), I, Summer 1938.

Effect of sheet metal roofs on interior temperatures, William Dan Scoates, M.S. (Ag.Eng.), I, Summer 1938.

Operating characteristics of pneumatic and rigid transport wheels for farm equipment, Harold Jonathan Thompson, M.S. (Ag.Eng.), Spring 1939.

Soil and water conservation techniques applicable to conditions in the Union of South Africa, Jacobus Adriaan Vorster, M.S. (Ag.Eng.), Spring 1939.

University of Iowa

Action of bentonite on the colloidal systems of sewage, Richard James Box, M.S., June 1939.

Hydraulic characteristics of a navigation lock with floor culverts, Miles Merrill Dawson, M.S., June 1939.

Chinese river control during the 16th century, Fa Yao Wong, M.S., June 1939.

The hydraulics of culverts, Arthur Rowe Luecker, M.S., January 1939.

Discharge coefficients of Tainter gates, Edward Sinclair Pretious, M.S., January 1939.

The clarification of highly turbid waters with natural clays, Harold Amondin Sage, M.S., January 1939.

The hydraulics of tainter gates, Ross Nyman Brudenell, M.S., August 1938.

Experiments on waves in rectangular channels, Victor A. Koelzer, M.S., June 1939.

Complete design of a reinforced concrete arch bridge, consisting of three 200 foot spans, Mukadder Hayri Mimaroglu, M.S., June 1939.

Traction of pebbles by flowing water, Chen-Hsing Yen jointly with John Bogardi, M.S., August 1938.

University of Kentucky

A condition survey of eleven hundred miles of concrete pavement constructed by the Kentucky Department of Highways, Louis Campbell, C.E., 1938–39.

Lehigh University

The balanced design of reinforced rectangular concrete beams, K. C. Cox, M.S. in C.E., June 1939.

Louisiana State University

A study of the effect of deep drainage on the culture of sugarcane and corn, Edgar Gregson Brown, M.S. in Ag.Eng. (The Louisiana State University, Abstracts of Theses, Vol. 31 N.S., No. 1, pp. 32–33, 1939).

The application of aerial photography to land measurements under the Agricultural Adjustment Administration program, Charles J. Hutchinson, M.S. in Ag.Eng. (*Ibid.*, Vol. 31 N.S., No. 1, p. 33, 1939).

Transportation of materials by hydraulic dredges, Walter Sharman Mask, M.S. in C.E. (*Ibid.*, Vol. 31, N.S., No. 1, pp. 46–47, 1939).

Drainage basin characteristics of City Park Lake drainage basin, Jesse Weiner, M.S. in C.E. (*Ibid.*, Vol. 31 N.S., No. 1, pp. 46–48).

Massachusetts Institute of Technology

Development and analysis of a device for measuring compressive stress in concrete, Roy Washington Carlson, D.Sc. in C.E., June 1939.

Development of an electrical strain gage and its application to the stress problem in elevated water tanks, Johann Hans Meier, D.Sc. in C.E., June 1939.

Planning for express traffic in metropolitan areas, Richard Lewis Steiner, N. City Plan., June 1939.

Determination of the stress distribution between rivets by photoelasticity, Wilbert Milton Bjork, M.S. in C.E., June 1939.

Experimental investigation of hydraulic losses in ninety-degree pipe bends, Raphael Hirsh Courland, M.S. in C.E., June 1939.

Determination of suspension bridge stresses by model study, James Westwood Greely (with W. C. McClure, '38), M.S. in C.E., June 1939.

Experimental investigation of the action of structures stressed beyond the elastic limit, Ernest Roy Hyman, M.S. in C.E., June 1939.

Model study of the buckling of members carrying transverse loads, Frederick Goodwin Lehman, M.S. in C.E., June 1939.

Effect of gradation on the shearing properties of a cohesionless soil, Thomas MacMaster Leps, M.S. in C.E., June 1939.

Studies of the sealing of concrete specimens for permeability tests, Francisco Javier Morales, Jr., M.S. in C.E., June 1939.

Study of bacterial respirators, George Matthew Reece, M.S. in Pub. Health Eng., June 1939.

Theoretical study of cylindrical shell roofs with overhangs, Hendrik Cornelissen Salzedo, M.S. in C.E., Dec. 1939.

Studies in bond between concrete and reinforcing steel, Shantaram Mahadeo Dahanukar, M.S. in C.E., Dec. 1939.

Experimental study of stress analysis with celluloid models, Samuel Davis, M.S. in C.E., Dec. 1939.

Experimental investigation of the effect of angularity of approach on the discharge coefficient of a dam with a roller gate, Frederick Otto Diercks, and Noel Houk Ellis, M.S. in C.E., Dec. 1939.

Experimental investigation of the upper and lower critical velocities for open channels, John Henderson Dudley, M.S. in C.E., Dec. 1939.

Experimental investigation of the variation of the coefficient of friction with Reynolds' Number for open channel flow, Raymond John Harvey, and Craig Smyster, M.S. in C.E., Dec. 1939.

Variation of permeability of sands with physical properties, Thomas Jay Hayes, III, and John David McElheny, M.S. in C.E., Dec. 1939.

Investigation of the influence of air content on the permeability of fine sands, Fritz Darmstaedter Helversen, M.S. in C.E., Dec. 1939.

Experimental investigation of the upper and lower critical velocities for open channels, James Chase Howland, M.S. in C.E., Dec. 1939.

Experimental investigation of the effect of variations in Reynolds' Number upon the coefficient of friction in open channel flow, Arthur Milton Jacoby, and John Herbert Kerkering, M.S. in C.E., Dec. 1939.

Experimental investigation of the buckling of compression members due to longitudinal loads, Albert Otto Jarvi, M.S. in C.E., Dec. 1939.

Model study of suspension bridge action under lateral loads, Giro Gerald Kubo, M.S. in C.E., Dec. 1939.

Study of methods of determining flood damages and of evaluating flood control benefits, James Benjamin Lampert, M.S. in C.E., Dec. 1939.

Effect of temperature upon the rate of floc formation, Darrell Astor Root, M.S. in San. Eng., June 1939.

Frictional resistance with pressure gradient, George Winston Bailey, and E. A. Wright, M.S. in Naval Const., June 1939.

Moment indicator applied to full scale structures, Walter Eugene Baranowski, and E. R. Tilburne, M.S. in Naval Const., June 1939.

Suction of soils on submerged bodies, Edgar Hadley Batcheller, and A. M. Chambliss, M.S. in Naval Const., June 1939.

Investigation of an axial flow fan, Charles Henry Gerlach, and G. C. Wells, M.S. in Naval Const., June 1939.

Pressure tendencies computed from the turning of the gradient wind with elevation, Edward Morgan Brooks, M.S. in Meteor., June 1939.

Isentropic analysis of a thunderstorm situation, Walter Sam Denham, and Denys William Knoll, M.S. in Meteor., June 1939.

Isentropic analysis of upper-air data obtained from airplane and jaumotte soundings during the period of heavy rainfall over the Gulf States, September 26–October 3, 1937, Leo William Welch, M.S. in Meteor., June 1939.

Filling of the New England hurricane of September 1938, Raymond Wexler, M.S. in Meteor., June 1939.

Observed transverse circulations in the atmosphere and their climatological implications, Harry Wexler, D.Sc. in Meteor., June 1939.

Design of a rigid frame bridge of eighty-foot span, Howard James McCrodden, M.S., June 1939.

Settlement study interrelating building frame stresses and soil stresses, Roger Hoyt Wingate, M.S., June 1939.

Development of precise speed control equipment for seismograph recording drums, Arthur Claude Ruge, D.Sc. in C.E., Dec. 1939.

A rehabilitation study for the Roxbury District in Boston, Charles Alexander Blessing, M. in City Plan., December 1939.

The selection and planning of industrial areas, Walter Andrew Wachter, M. in City Plan., December 1939.

Comparative biological effects of 200 and 1,000 kv X-rays, John Allen Hilcken, M.S. in Biol.Eng., December 1939.

Experimental investigation, by means of models, of negative pressures on a spillway section of a dam, Joseph Kin Hing Leung, M.S. in C.E., Dec. 1939.

Model study of erosion below the right wing wall of the Fort Peck dam tunnels, Kenneth Einar Madsen, and John Brockway Rippere, M.S. in C.E., Dec. 1939.

Some theoretical considerations on the one-dimensional consolidation of clay, Wilfred Merchant, M.S. in C.E., Dec. 1939.

Model determination of structural constants for members of variable moment of inertia, Verne N. Osmundson, M.S. in C.E., Dec. 1939.

Experimental study of the effect of joints in rigid frame analysis, John William Pecock, M.S. in C.E., Dec. 1939.

Study of the multiple-use reservoire for flood control, Judson Woodring Wark, M.S. in C.E., Dec. 1939.

Experimental studies of the shearing strength of floc particles, Albert Percival Dennis, M.S. in San. Eng., Dec. 1939.

Isentropic analysis of a case of cyclogenesis, Roland John Boucher, M.S. in Meteor., Dec. 1939.

Design for a continuous truss bridge, Justin Joseph Francis, M.S., Dec. 1933.

Stresses in concrete walls caused by shrinkage of the concrete, Thomas James Reading, M.S., Dec. 1939.

McGill University

The effects of certain factors on the properties of portland cement concrete, T. K. Hum, M.Eng. (C.E.), May 1939.

Michigan State College

Design, disposal plant Michigan Sugar Company's Lansing factory, Frederick J. Cook, M.S. in C.E., June 1939.

University of Michigan

A qualitative analysis of surface run-off, Chas. F. Bird, M.S.E. (C.E.), June 1939.

A sanitary engineering program for the Island of Hainam, Ping Fang Chen, M.S.E. (C.E.), June 1939.

A study of plant design standards in sanitary engineering, Thos. G. Croom, M.S.E. (C.E.), June 1939.

The extent commercial motor vehicles can be used by the army for transport in the event of war, Chas E. Smith, M.S.E. (Trans.), June 1939.

Public health work in rural areas in time of floods, Harvey G. McAndrews, M.S.P.H.E., June 1939.

Analysis of continuous slabs, Chao Wan Pan, Sc.D., February 1939.

Deformation of beams involving ductile behavior, Erman Orchard Scott, D.Sc. (Eng. Mechanics), June 1939.

Stresses and displacements in a hollow circular cylinder, Carl Willard Nelson, Ph.D. (Eng. Mechanics), June 1939.

Concerning the strength of figure formula in triangulation, Clarence George Tobias Stipe, Ph.D. (Geodesy and Surveying), 1939.

A coördinated system of railroads for China, Eugene Wen Ping Lee, Ph.D. (Transportation), 1939.

University of Minnesota

Ionic effects upon the rates of settling of fine-grained sediments, Lloyd Robert Dreveskracht, M.S. in Geol., June 1939.

The development and construction of a radio meteorograph with a four-second cycle for the automatic recording of pressure, temperature and relative humidity, Harold Reinert Larsen, M.S. in Aero. Eng., June 1939.

A study of insulated wall and ceiling construction based on temperature measurements under operating-conditions, David Bernhard Anderson, M.S. in Arch. Eng., June 1939.

Eccentric loads on reinforced concrete sections, Charles Eugene Cutts, M.S. in C.E., June 1939.

A study of run-off of drainage area and the factors which cause and affect it, Russell Marble Cornell, M.S. in C.E., Dec. 1938.

Structural steel bridge columns, Lawrence Theodore Wyly, M.S. in C.E., Dec. 1938.

The effect on the drag of a streamlined body caused by air jets normal to the surface of that body, Frank Benhardt Sandgren, M.S. in Aero. Eng., March 1939.

Some interesting structures in Hawaii, Russell Charles Brinker, M.S. in C.E., March 1939.

Mississippi State College

Safety organization and administration in the small construction industry, Richard Charles Carson, M.S. in C.E., Aug. 1939.

Missouri School of Mines and Metallurgy

Coördination of the transportation systems of the United States, Herman Blickensderfer, M.S. in C.E., May 1939.

Design study of a three span continuous tied-arch bridge, George Perry Steen, M.S. in C.E., May 1939.

Montana State College

Extensional blanket analysis of traffic surveys, Thayer F. Stoddard, C.E., 1939.

University of Nebraska

Optimum spacing of basin-lister dams and the draft of attachments used to form the dams, Lester Frederick Larsen, M.S. in Ag.Eng., June 1939.

Evaluation of mineral fillers for low-cost bituminous roads, Raymond Emerson Bollen, M.S. in Eng. Mechanics, June 1939.

The organization and management of large construction projects, George Kinney Leonard, C.E., June 1939.

University of New Hampshire

The flow of water over horizontal circular weirs, Salvatore Grasso, M.C.E., June 1940.

New York University

Sulphur compounds in water and sewage treatment, John J. Coates, M.C.E. (San.), June 1939.

The incineration of sewage sludge, Edward S. Cole and Richard Stockman, M.C.E. (San.), June 1939.

A study of the efficiency of sedimentation of raw sewage in a multiple tray, horizontal flow, sedimentation tank, Edward C. LaVallely, M.C.E. (San.), June 1939.

Friction loss relationships for airflow in a 2½" iron pipe, Thomas D. Randall, M.C.E. (San.), June 1939.

Rapid filtration of clarified sewage, Alexander Rihm, Jr., and Joseph Salvato, Jr., M.C.E. (San.), June 1939.

Corrosion of water mains (causes, effects, remedies, prevention), J. Thomas Wankmuller, M.C.E. (San.), June 1939.

Activated carbon in sewage and industrial waste treatment, Roy F. Weston, M.C.E. (San.), June 1939.

North Carolina State College

The distribution of horizontal forces in precast concrete pile tresile bents, Duncan Thomas Memory, C.E., June 1939.

Load distribution on timber highway bridges, Dan Lipschutz, M.C.E., June 1939.

T-beam action of a concrete slab and the supporting stringers, Robert Ivey Simkins, M.C.E., June 1939.

University of North Dakota

The influence of activated silica in sewage coagulation, Conrad W. Christenson, M.S., 1939. (Transactions, American Institute of Chemical Engineers, 36, 71, 1940.)

Studies on the resistance of various strains of B. Coli and B. Typhosi to chlorine and chloramine, Stephen Francis Smith, M.S., 1939.

Ohio State University

Contributions of the photo-elastic method of stress analysis, Royal Weller, Ph.D. (Department of Physics and Astronomy. Ohio State University, Abstracts of Doctoral Dissertations, No. 30, pp. 227–236, 1939.)

The effective moment of inertia of riveted plate girders, Samuel Theodore Carpenter, M.S. (Ohio State University, Abstracts of Masters' Theses, No. 30, pp. 20–21, 1939.)

Analysis of stresses in railway truck side frames by the moment distribution method, James Clinton Settles, M.S. (*Ibid.*, No. 30, pp. 108–109, 1939.)

Pennsylvania State College

Analysis of a rigid-frame bridge. A comparison of the results obtained by the methods of slope-deflection and photoelasticity, Arnold Oestreicher Ostrand, M.S. in Str.Eng., 1939.

Heating the sludge compartment of an Imhoff tank, Frank Alexander Tebo, M.S. in San.Eng., 1939.

Tests for determining the engineering properties of the soil, Robert Bruce Yorke, Jr., M.S. in A.E., 1939.

University of Pittsburgh

Investigation of test procedure for determining the per cent of binder to be used in tar road mixtures, Frank Bromilow and Jack R. Clanton, M.S., June 1939.

Ignitron spot welding control (Problems in development), John Ward Dawson, M.S., June 1938.

Hydraulics of the Tygart River Reservoir, Robert M. Morris, C.E., June 1939.

The application of the Bureau of Air Commerce specification requirements to soil stabilization with coal tar, Paul F. Phelan, M.S., June 1938.

Weathering tests of limestones, Martin L. Rutter, M.S., June 1939.

Calibration of an automatic proportionating liquid-gas valve, Stephen G. Zeleznjak, M.S., June 1939.

Princeton University

Design of a single-story rigid-frame building, A. J. Barzaghi (C.E.).

Model analysis of North Avenue Station, State Street Subway, Chicago, Ill., D. H. Crater (C.E.).

Purdue University

An investigation of the design of railway wheel tread contours, Frank Harold Smith, M.S. in Eng., Aug. 1938.

Compression tests on stabilized soil mixtures, Ronald Ira Mays, M.S. in Eng., June 1939.

Methods of observation of seepage through earth dams, James Arthur Richardson, Jr., M.S. in Eng., June 1939.

Frost action in stabilized soil mixtures, Harlan Frank Winn, M.S. in Eng., June 1939.

The rigid frame analysis, Ih-Tsing Yen, M.S. in Eng., June 1939.

Rensselaer Polytechnic Institute

Design of heating and air conditioning systems for the Marine Officer's School, Quantico, Va., Lewis Crocker Coxe, M.C.E., June 1939.

Design for a rigid frame seaplane hanger, span 160 feet, Ernest Siewert Bathke, M.C.E., June 1939.

An investigation of the effects of austenitic grain size in relation to the arc welding of low and medium carbon steels, Richard L. Mann, M.C.E., June 1939.

An investigation of the maximum moments in continuous structures, Robert James Hammond, M.C.E., June 1939.

A study of stresses in a drydock caisson, James Robert Davis, M.C.E., June 1939.

An economic study and design for a Diesel generating station, Neil Edgar Kingsley, M.C.E., June 1939.

Comparative studies and design for a naval dry dock, William Campbell Gibson Church, M.C.E., June 1939.

Design for a double destroyer drydock and generating station for a Navy Yard in Alaska, Lewis Milton Davis, Jr., M.C.E., June 1939.

A comparison of the approximate and the exact methods of computing secondary stresses in a bridge truss, Eduard Pestel, M.C.E., June 1939.

An investigation of the sub-aqueous deposition of concrete, Carter Laurence Shea, M.C.E., June 1940.

An investigation of the theory of elasticity as applied to lateral stresses in sand, and a comparison with observed results for various types of surface loading, Dean Freeman Peterson, Jr., D.C.E., June 1939.

South Dakota School of Mines

Vacuum tempering of wheat, Vincent George Lauters, C.E., 1939.

The design, construction, and maintenance of stockwater impounding dams in the Northern Great Plains Region, Donald Lischer Roberts, C.E., June 1939.

Some technical aspects in the design of low cost bituminous roads in Arizona, Wayne Gilder O'Harra, C.E., June 1939.

Analysis of a member with elastic supports, Philip Bruce Ramsey, C.E., June 1939.

University of Southern California

Legislation in California for earthquake resistant construction of public schools, George Leon Gardner, M.S. in C.E., June 1939.

Economics of cantilever and conterfort retaining walls, Reed James Gattmann, M.S. in C.E., June 1939.

Transmission line tower design, William Archie Hunsucker, M.S. in C.E., June 1939.

Stanford University

Varied flow in a rectangular open channel, Charles McLain Adams, Engr. (C.E.), June 1939.

An investigation of the high temperature effects on portland cement mortar, Arthur Aaron Hoffman, Engr. (C.E.), April 1939.

Methods of successive approximations for the analysis of statically indeterminate systems, Robert Richard Matheu, Engr. (C.E.), June 1939.

Weaknesses in building regulation as revealed by an analysis of engineering provisions of current building codes, Kenneth Burr Reynolds, Engr. (C.E.), June 1939.

Stevens Institute of Technology

The flow of compressible fluids through a square-edged orifice, Kenneth G. Berrian, M.S., June 1939.

Syracuse University

Analytical investigation of methods of determining the scale and the tilt of an aerial photograph, Raymundo J. Heredia, M.C.E., June 1939.

University of Tennessee

The treatment of high-fluoride waters with orthophosphoric acid and lime, John Edwin Greer, M.S., August 1939.

Comparative analysis of stresses in a building frame, Walter Clyde Hutto, M.S., August 1939.

Photoelastic analysis of stress, Allen Jones, III, M.S., August 1939.

A. and M. College of Texas

The cost of water from irrigation wells in Texas, Robert Claude Forrest, M.S. in Ag.Eng., June 1939.

Studies of winter hibernation of anopheles larvae at College Station, Texas, and vicinity, William Charles Gauntt, M.S. in Mun. and San.Eng., June 1939.

A study of power and equipment for cotton production in the Brazos River Valley, Norman Elmo Leach, M.S. in Ag.Eng., June 1939.

A study of a low-wattage, non-pressure, electric water heater for Texas dairies, John Clifton McWhorter, M.S. in Ag.Eng., June 1939.

A survey of anopheline larvae and breeding places at College Station, Texas, Arturo Luis Berti, M.S. in Mun. and San.Eng., August 1939.

A study of some methods of analyzing statically indeterminate structures by means of models, John Cash Bridger, M.S. in C.E., August 1939.

Distribution of adult anopheline mosquitoes at College Station, Texas, and vicinity, Mario Montesinos, M.S. in Mun. and San.Eng., August 1939.

University of Texas

Some investigations as to the effect of thickness of sample in the soil mechanics consolidation test, Rudolph George Mueller, Jr., M.S. in C.E., June 1939.

A review of the fluoride problem in potable waters and a study of the lime-soda method of treatment, Herman Kelley Clark, M.S. in San.Eng., August 1939.

Tulane University

The determination of backwater curves in uniform channels and natural water courses and a comparative analysis of various methods of computation, Leonard Reginald Kirst, C.E. (Tulane University, Abstracts of Theses, Series 40, No. 15, pp. 80–81, 1939.)

An application of the column analogy and the method of moment distribution to the design of a highway overpass, Frank Whitmore Macdonald, C.E. (*Ibid.*, Series 40, No. 15, pp. 81–82, 1939.)

Modern timber design, Howard James Hansen, C.E. (*Ibid.*, Series 40, No. 15, pp. 79–80, 1939.)

Outline for soil mechanics laboratory, Carroll Lee Wood, Jr., C.E. (*Ibid.*, Series 40, No. 15, pp. 82–84, 1939.)

Utah State Agricultural College

Farm reservoirs, Eldon M. Stock, M.S., 1939.

Virginia Polytechnic Institute

An investigation of the effects of freezing on Portland cement concrete, Edward Harman Fuller, M.S. in C.E., 1939.

A study of the efficiency of operation of the Viriginia Polytechnic Institute sewage disposal plant, John Walter Johnson, Jr., M.S. in San.Eng., 1939.

The effect of contour furrows on soil and water losses in pastures, Richard Elbert Brown, M.S. in Ag.Eng., 1939.

A partial study of the use of Tennessee Valley Authority phosphate fertilizer in soil and water conservation, Walter Howard Dickerson, Jr., M.S. in Ag.Eng., 1939.

A partial study of the effects of slope and soil on the erosion conditions of a sixty-two acre watershed, Ralph Emerson McKnight, M.S. in Ag.Eng. 1939.

Washington State College

Design and technical aspects of frozen earth dam at Grand Coulee Dam, Lloyd Vernon Frooge, M.S. in M.E., June 1939.

West Virginia University

Evaluation of a toll bridge, Lyle E. Laugfitt, C.E., June 1939.

University of Wisconsin

Performance of a mechanical aeration-diffused air-activated sludge sewage plant at Verona, Wis., Laurence Earl Bidwell, M.S. in C.E., June 1939.

Water application efficiency studies with special reference to Utah work, Wayne D. Criddle, M.S. in C.E., June 1939.

Investigation of methods used in the design of self-anchored suspension bridges, Eu-dien Li, M.S. in C.E., June 1939.

Effect of viscosity and surface tension on orifice coefficients, Edward Arthur Menuez, M.S. in C.E., June 1939.

Influence lines for continuous reinforced concrete arches on high elastic piers, Kenneth Peter Norrie, M.S. in C.E., June 1939.

Yale University

Reinforced concrete columns in flexure, Robert Austin Jackson, M.Eng. (C.E.), June 1939.

(To be concluded in the April, 1941, JOURNAL OF ENGINEERING EDUCATION.)

MECHANICAL ENGINEERING PAGE

I consider the honest engineer the most valuable asset of this government.—Wm. H. Taft.

R. L. SWEIGERT, Georgia School of Technology, *Editor*

COMMENTS ON OBJECTIVE TYPE TESTS

W. C. JOHNSON
Virginia Polytechnic Institute

For my freshman course in Introduction to Engineering I have been working a good deal with the objective or short-form tests. These tests may be of two kinds, recall, or recognition, depending upon whether the student is required to supply words from memory or whether he simply recognizes the answer as given on the sheet. Professor Faires seems to have discussed only the recognition type. An example of the recall type might be as follows:

> "The American Telephone and Telegraph Company found that the best indication of probable success was given by what one thing in a man's college record?"
>
> Ans.....

The recall type of question can be practically as objective as the recognition type.

In deciding whether a question is good or not, I compare the papers of the top fifth of the class with those of the bottom fifth of the class by figuring the percentage obtained by the average man of each group. The difference between the two percentages gives the ability of the question to distinguish between good men and poor men. The percentages themselves give an indication of the difficulty of the question.

One of the important things in assigning grades to students is to drop the idea that everything must be finally in percentages. Dr. C. V. Mann in his book "Objective Type Tests in Engineering Education" discusses this very ably and gives one method of assigning grades according to percentile ranks. I prefer to do it in a somewhat similar way, based on what is virtually a standard score.

EDITORIAL COMMENT

We study the various aspects of engineering problems requiring solution, and we are never satisfied until we have put the results to the test. But to make the tests worthwhile, various new and accurate measuring devices have been developed.

In our educational work, in which we are dealing with complex conditions, we are still using measuring instruments of quite doubtful accuracy, and little attention has been paid to the development of reliable and accurate measuring devices. Why should we not have such measuring devices that we could measure the degree of success we might have in attaining any particular educational objective?

Rarely is any degree of reasonably accurate measuring done. We merely hope the results are what we want. Rating student achievement and progress is one of those items that needs improving. As others have previously stated: "Are graduates good because of the processing we have put them through, or in spite of the processing we have put them through?"

NECROLOGY

PROFESSOR BRECKENRIDGE

LESTER PAIGE BRECKENRIDGE, 1858–1940

The Yale Engineering Association records with profound sorrow its sense of loss in the death of Lester Paige Breckenridge, honorary member, Professor Emeritus of Mechanical Engineering at the Sheffield Scientific School, Yale University under whose energetic leadership the Association was formed.

Graduated from the Sheffield Scientific School in 1881, Professor Breckenridge followed his former instructor, Joseph F. Klein, to Lehigh University in 1882, where he began a long and useful career as an educator of engineering students. Into the academic atmosphere of the engineering schools of that day Professor Breckenridge injected the realistic spirit of a young man who had learned a trade and had worked with some of the best known engineers of his day. A sympathetic understanding of men and women of all ages, a tactful skill in assisting them in the solutions of their problems and inspiring them to exert their best efforts, a boundless energy sustained by robust health, an enthusiastic zeal in the prosecution of whatever came to his hand to do in work or play, vitalized the atmosphere in which he moved.

As opportunity presented Breckenridge moved on to broader responsibilities; to the Michigan State Agricultural College in 1891, to the University of Illinois in 1893, and to his Alma Mater in 1909. Wherever he went the education program of the institution he served expanded and increased its strength. The services of the schools, their faculties, and their students were developed on behalf of the public and industry with reciprocal benefits to all who rendered them. He brought engineering education into the public and professional eye. He made engineering schools the partners of state and industry. He enriched teacher and pupil by encouraging them to undertake research, and industry and engineering knowledge by the results obtained through these researches. Wherever he went he earned the respect and affection of all who met him and the influence of his personality remained long after he had left. Hundreds of "Breck's boys" the world over mourn his death and will cherish the memory of a spiritual and intellectual stepfather whose influence will remain with them always.—*For the Yale Engineering Association: E. M. T. Ryder, George Sutherland,*

George A. Stetson.—Reprinted from *The Yale Scientific Magazine*, Fall, 1940.

ERIC THERKELSEN

Eric Therkelsen, Professor of Mechanical Engineering and Head of the Department, Montana State College, died February 15, 1941.

Eric Therkelsen died after a brief illness following a heart attack. His undergraduate work in Mechanical and Electrical Engineering was taken at Washington State University, the Master's degree in Mechanical Engineering at Montana State College, and Doctor of Engineering at Technische Hochschule, Charlottenburg, Germany. He was a member of many technical and honorary scientific societies; he was an active member of the Church, educational and civic organizations of his community. His death is a serious loss to the Engineering Division of Montana State College.

DAYTON CLARENCE MILLER

The Case School of Applied Science has suffered a great loss in the death of her noted physicist, Dr. Dayton C. Miller, on February 22, at the age of 74 years.

Dr. Miller had taught at Case for more than fifty years and had been head of the department of physics from 1893 until his retirement as honorary professor of physics in 1936. In 1927 he had been made Ambrose Swasey research professor of physics. Upon his retirement in 1936 the Case Trustees bestowed upon him the title, "Honorary Professor of Physics" for life, and at their request he continued as acting head of the department until the fall of 1939.

SECTIONS AND BRANCHES

The officers for the **North Carolina State College** Branch S. P. E. E. for the school year, 1940–'41, are: Professor F. W. Lancaster, Chairman, Professor F. F. Groseclose, Vice-Chairman; Dr. A. M. Fountain, Secretary and Professor G. G. Fornes, Corresponding Secretary.

State College has its largest enrollment of 1326 students in engineering this quarter. The majority of the engineering students are registered in the Department of Mechanical Engineering, with most of the freshmen requesting information regarding courses in diesel engineering, aeronautics, and air conditioning.

Five major meetings for this year are planned with the final meeting being a Dinner meeting and also "Ladies Night."

G. G. FORNES,
Secretary

S. P. E. E. TENTATIVE SCHEDULE

Date	*In Charge of Program*	*Topic*
Nov. 21, 1940	Professors Mumford and Lancaster	Placement Tests
Jan. 9, 1941	Professors Parker and Paulson	Discussion on National Defense
Feb. 13, 1941	Professors Fouraker and Massey	Engineers and Engineering Economics
April 10, 1941	Professors Bain and Fontaine	Suggested Methods of Registration
May 8, 1941	Professors Clark and Fornes	Art in Engineering (Dinner meeting)

With the exception of the May meeting:
Time: 5:00 P.M.
Place: 207 Daniels Hall.

A. M. FOUNTAIN,
Secretary

The **Northeastern University** Branch of the Society held a meeting at Northeastern University, Boston, on January 21, 1941.

The members and guests enjoyed dinner at the University at 6:00 P.M., following which Professor Chester P. Baker, President of the Section, welcomed the guests. The remainder of the meeting was given over to a panel discussion of the topic, "What Makes the Coöperative Plan Function." The panel was composed of members of the Section and executives from firms coöperating with Northeastern University.

The following men presented five-minute papers relating to the main topic: Harry Kerr, President of Boston Gear Works, Inc.; H. C. Hamilton, Laboratory Superintendent of Boston Edison Company; E. H. Land, President of Polaroid Corporation; M. N. Clair, Vice-President of Thompson Lichtner Co., Inc.; F. T. Lewis, Production Manager of General Electric Company; W. C. White, Dean of the College of Engineering, Northeastern University; C. P. Baker, Chairman of the Department of Chemical Engineering; C. A. Muckenhoupt, Chairman of the Department of Physics; W. E. Nightingale, Director of Coöperative Work; T. L. Wheeler, Vice-President of Arthur D. Little, Inc.; E. W. Manning, Billing Manager of the Pepperell Manufacturing Corporation; W. G. Webster, Engineer, General Radio Company.

The panel discussion centered around the following topics: (1) Why Do I Hire Coöperative Students? (2) What Should Cooperative Students Expect from Industry? (3) On What Jobs Do I Find Coöperative Students Can Be Used to Best Advantage? (4) What Should Be Expected by Industry of the Coöperative Student? (5) What Special Problems Does the Employment of Cooperative Students Create? (6) How Can the Coöperative Plan Best Function as an Educational Method?

Lively debate from the floor followed the panel discussion and the meeting was closed by Mr. Kerr who expressed his gratification for the success of the meeting. Dean White expressed the pleasure of the Section in collaborating with the guests in this meeting. Both sides agreed that a closer contact and appreciation of the other's problems would result in an increased success of the Cooperative system.

L. F. CLEVELAND,
Secretary

The ninth annual meeting of the **Pacific Southwest Section,** S. P. E. E., was held at The University of Southern California, in Los Angeles, on December 27th and 28th, 1940. More than 75 attended, some coming from as far away as Arizona and Utah. Fifteen colleges, 4 junior colleges, 4 commercial concerns, and 2 publishers were represented.

The first session was held in one of the fine class-rooms with a welcome and announcements by Professor P. S. Biegler, U. S. C., Chairman of the Section. Three papers were presented and discussed: A Suggested Course on Engineering Administration for Petroleum Engineers, by J. F. Dodge, U. S. C.; Chemical Engineering and Its Relationship to the Petroleum Industry, by R. E. Vivian, U. S. C.; and Teaching Engineering Students, by G. L. Sullivan, University of Santa Clara.

At luncheon the Section was officially welcomed by Dr. Rufus B. von KleinSmid, President of The University of Southern California. In addition there was a very interesting illustrated talk by Mr. Julian Hinds, Assistant Chief Engineer, Metropolitan Water District, on the Colorado River Aqueduct.

The Friday afternoon session contained the following papers with discussions of each: Training the Imagination, by H. R. Kepner, Utah State Agricultural College; Engineering Registration as it Affects Engineering Graduates, by H. M. Jones, Secretary, Board of Registration for Civil Engineers, State of California; Problems in Secondary Education which Affect Engineering Colleges, by F. B. Lindsay, Assistant Director of Secondary Education, California State Board of Education. The last two papers, especially, elicited much interested discussion.

The annual dinner of the Section was held on Friday evening with genial Professor Eyre, U. S. C., acting as toastmaster. The group was entertained wiht several excellent violin numbers rendered by a student musician. J. E. Harley, U. S. C., talked on The United States at the Cross Roads in World Affairs. Following this Dean Vivian showed some fined colored movies taken during a recent visit to Palestine and Geneva.

The third session, Saturday morning, had a decidedly areonautical atmosphere, the papers being: What the Aircraft Industry Expects of the Engineering College, by C. T. Reid, Director of Education, Douglas Aircraft Company, Inc.; Engineering Training for the Aeronautics Industry, by R. R. Irwin, Lockheed Aircraft Corporation, (read by Mr. V. J. Hydar of the same organization); The Work of the Advisory Committee on Engineering Education for National Defense, by B. M. Woods, University of California.

The tone set by the morning session was continued at luncheon when C. F. Lienich, Assistant Regional Director, Civil Aeronautics Administration, spoke on The Relationship of the Civil Aeronautics Administration to Engineering Colleges.

The fourth and final session on Saturday afternoon was comparatively short with one paper Some Observations Related to the E. C. P. D. Accrediting Program, by G. M. Butler, University of Arizona. After discussion of the paper came the annual business meeting at which the following officers were elected for the year 1941: Chairman, H. H. Wheaton, Fresno State College; Vice-Chairman, C. T. Wiskocil, University of California; Secretary-Treasurer, E. D. Howe, University of California; members of Executive Committee, T. C. Adams, University of Utah, J. A. Carpenter, University of Nevada, H. R. Kepner, Utah State Agricultural College. It was voted to hold the next annual meeting at Fresno State College on December 29th and 30th, 1941.

While the men were attending the sessions recorded above, their ladies were being entertained in various ways by a committee of local ladies headed by Mrs. P. S. Biegler and Mrs. D. M. Wilson. High points were an art tour of the Campus to view the many fine buildings and other art features, a trip to the Los Angeles Museum in nearby Exposition Park which has some very fine collections, and a luncheon in picturesque Olivera Street which is a tiny block in the old part of Los Angeles maintained as it once was in the early days.

This year it was found impossible to schedule the meeting for more than two days, whereas in the past three days have always been available. In spite of this reduction in time the ninth annual meeting was easily the equal of any previous meeting in hospitality, content, attendance, and sociability.

BOYNTON M. GREEN,
Secretary-Treasurer, 1940

The new officers for the **North Midwest Section** are:

Chairman—G. L. Larson, University of Wisconsin.
Vice Chairman—L. O. Stewart, Iowa State College.
Secretary-Treasurer—L. F. Van Hagan, University of Wisconsin.

Executive Board

G. C. Priester, University of Minnesota.
R. W. Ludt, Marquette University.
C. T. Eddy, Michigan College of Mining and Technology.
J. W. Howe, University of Iowa.

The Seventh Annual meeting of the section will be held at the University of Wisconsin in Madison, sometime in October.

L. F. VAN HAGAN,
Secretary

COLLEGE NOTES

The **Clemson College** enrollment is nearly 2,350—a record figure. Acceptance of applications for enrollment was discontinued in the early summer, barracks space being fully reserved. The college has participated in the National Defense Program extensively. Civil Aeronautics training, both primary and secondary, has been given to over 150 students. Numerous of these men have gone into military flying service. Training in auto mechanics, blacksmithing, machine tool design, drafting, woodwork, electricity, and welding has been given to two groups of National Youth Administration students, about two hundred in all. At present classes are being held at night for about 100 Works Progress Administration men from territory adjoining the college because the facilities are being fully used during the day.

Several changes and additions have been made in the engineering faculty: A. M. Quattlebaum, B.S., Clemson, '34, M.S., Cornell, '35, has returned as Assistant Professor of Civil Engineering, after a year at the University of Iowa, working toward a doctorate on an appointment as a Teaching Fellow. L. A. Perry, B.S., Clemson, '37, who filled the position on a temporary basis, has returned to the State Highway Bridge Department. C. N. Gaylord, B.S. in C.E., Ohio University, '30, M.S.E., University of Michigan, '36, has been appointed instructor of Civil Engineering. Mr. Gaylord has had practical experience in structural design and has been a member of the engineering faculty and supervisor of construction at Hampton Institute for the past ten years. H. W. Dougherty resigned the position to accept reappointment in construction work with the Tennessee Valley Authority. H. M. Wachter, B.S. in C.E., Oregon State College, '39, has been added to the staff as instructor in Mechanics and Hydraulics. Mr. Wachter did graduate work at the University of Iowa last year. L. A. King, B.S. in E.E., University of Tennessee, '38, M.S. in E.E., University of Missouri, '40, has been appointed instructor of Electrical Engineering. Mr. King has had practical experience, in the Coöperative course of the University of Tennessee, for the Eastern Tennessee Power Company, and was a teaching fellow for the three semesters he was working on his advanced degree at the University of Missouri. S. M. Watson, A.B., Elon College, '36, B.S., North Carolina State College, '37, has been added to the Mechanical Engineering staff. Mr. Watson had two years of teaching experience at North Carolina State

before coming to Clemson. D. W. Bradbury, B.S., Clemson, '40, has been appointed Assistant in Drafting to take the work formerly carried by G. A. Douglass, who recently was ordered to active duty as a First Lieutenant with the Armored Force School from his duties as a teaching fellow and a candidate for a master's degree at Virginia Polytechnic Institute. L. R. Ambrose, B.S., Clemson, '39, has been appointed instructor in Foundry and Machine Shop to take the work formerly carried by J. S. Branch, B.S., Clemson, '36, who resigned to accept appointment with the Agricultural Adjustment Administration. G. C. McMakin, B.S., Ch.Engr., Clemson, '40, has been appointed Assistant in Engineering to take the work previously carried by J. K. Chapman. Mr. Chapman resigned to take graduate work towards an advanced degree at the University of Michigan. G. E. Hoffman, B.Arch., Carnegie Institute of Technology, '36, Massachusetts Institute of Technology, '37, has been appointed Assistant Professor of Architecture to replace T. K. Fitz Patrick, who resigned to accept a position on the architectural faculty at Rice Institute. Mr. Hoffman was in architectural practice one year and has taught and done consulting work for the past two years at the Oklahoma Agricultural and Mechanical College. D. L. Parrott, B.S., Clemson, '40, has been appointed graduate assistant in Architecture. Additions have also been made to the secretarial, clerical, and library staff.

The past spring the college was the recipient of a distinctive gift from the class of 1915 in the form of an outdoor amphitheater built in a wooded valley on the campus. The stage is equipped with a water spray curtain with colored light effects, and an amplifier system.

Colorado State College.—The Civil Engineering department has this past summer inaugurated a summer course in the Fluid Mechanics taught by Professor Hunter Rouse of the Institute of Hydraulic Research at the University of Iowa. It is planned to continue this type of concentrated course offering (the class met twice daily for a three weeks' period) and if the demand justifies it to include additional courses of both graduate and undergraduate caliber in this summer school.

The Materials Testing Laboratory of the college has added several new items of equipment, including a 60,000 lb. hydraulic, Soutwark-Emery testing machine, a 10,000 inch-lb. torsion testing machine, an impact testing machine, a fatigue testing machine and a hardness testing machine.

The Hydraulic Laboratory has been improved by the addition of three closed water circuits for experimental and student work, each circuit being supplied with a circulating pump and auxiliary

storage tanks. A direct current electrical motor dynamometer and motor generator set have been added in order to carry on motor and turbine testing work. A new pelton wheel with a window for visual inspection has also been added.

The Electrical Engineering department has recently moved into new and enlarged quarters. This department now has adequate laboratory and classroom space to enable them to carry on an even more successful educational program than in the past.

The Mechanical Engineering department announces the addition of Alfred O. Schmidt (B.S., Jena; M.S., University of Michigan) whose major field is that of metals processing. This department is in charge of the Civilian Pilot Training work and is also participating along with the other departments in the new defense program.

Michigan College of Mining and Technology.—Charles M. Carson, who retired as head of the department of chemistry and chemical engineering late last summer, was named professor emeritus by the Board of Control at its final 1940 meeting, in a resolution praising Dr. Carson's twenty-seven years of service as department head. He had also taken the post of acting president a decade and a half ago, after the accidental death of President F. W. McNair, and served in this capacity until a successor to Dr. McNair was chosen.

Men newly appointed to the staff are Thomas E. Vichich as instructor in the department of mathematics and physics, to replace Dr. Kenneth Welker, who recently resigned in order to accept an industrial position; and Dr. L. Charles Hutchinson, instructor, replacing Associate Professor J. H. Service in mathematics and physics. Dr. Service was called to active duty a short time ago by the United States Naval Reserve, in which he is a lieutenant-commander. To replace him as coördinator of the Civil Aeronautics Authority program at Michigan Tech., the Board of Control has named Assistant Professor A. N. MacIntosh of the department of geological engineering. Professor MacIntosh was an officer of the Royal Flying Corps in the World War of 1914–18.

A secondary (advanced) and also an instructor-refresher course have been added to the C.A.A. offerings at this college.

Other national defense news includes the establishment, early in January, of an intensive twelve-week course in Engineering Drawing as part of the defense program, and the appointment of Dr. Henry L. Coles, head of the departments of chemistry and chemical engineering, as one of the workers on high-explosives research for the National Research Council. In this investigation,

Professor Coles will be aided by Professors Glenn Damon and Roy Makens. The Engineering Drawing work is directed by Associate Professor T. E. Richards, under the general supervision of Professor R. R. Seeber, head of the mechanical engineering staff.

M. J. Larsen has been promoted from instructor in Electrical Engineering to assistant professor.

The college recently purchased the John T. Reeder mineral collection for the A. E. Seaman Mineralogical Museum, which is housed on the campus. The nineteen hundred specimens added include an excellent selection of Copper Country minerals. Choice specimens from other well-known localities throughout the world are among the purchases.

Most important of recent curriculum changes are the replacement of the Bachelor of Science degree in Geology by a B.S. degree in Geological Engineering, and the setting up of four "majors"—in mathematics, physics, geology and chemistry—within the curriculum leading to the B.S. degree in General Science.

Numerous detailed changes, many of them consequent upon these major revisions, have also been recommended by the faculty and approved by the Board. Courses added total twenty-five; dropped, four; significantly changed, about ten.

Purdue University.—A new Physics Building and a new wing to the Electrical Engineering Building are under construction. The buildings are expected to be ready for use in September, 1941.

New members of the engineering staff are: *Applied Mechanics,* J. O. Hancock, instructor, A. S. Boksenbom, graduate assistant; *Civil Engineering,* O. J. Bush and L. E. Gregg, graduate assistants; *Electrical Engineering,* J. R. Eaton, instructor, J. A. DeShong, Jr., R. P. Stone, fellows; *General Engineering,* R. E. Strahlem, instructor; *Mechanical Engineering,* E. N. Kemler, associate professor, C. R. Freberg, J. A. Hordy, Nickolas Kulik, A. R. Spalding, instructors; F. M. Crosby, assistant instructor; W. L. Bergman, C. L. Frown, graduate assistants.

On February 1, Professor G. A. Young relinquished his duties as Head of Mechanical Engineering to become Senior Professor of Mechanical Engineering. Professor Young has carried the responsibilities of department head since 1912. He is succeeded by Professor H. L. Solberg, who will be aided by D. S. Clark as administrative assistant.

Yale University.—New appointees in the School of Engineering are Clarence W. Dunham, Assistant Professor of Civil Engineering; James A. Johnston, Instructor in Chemical Engineering; James Gordon Clarke, Instructor in Electrical Engineering; James

Lathrop Meriam, Instructor in Mechanical Engineering; Kenneth W. Lange and Herbert A. Sawyer, Assistants in Instruction in Civil Engineering, and Lloyd M. Watson, Assistant in Instruction in Chemical Engineering.

Mr. Dunham is a graduate of Rensselaer Polytechnic Institute 1920. Served in the World War as a second lieutenant of Infantry. After graduation he served for three years as Instructor at Rensselaer. Formerly Assistant Chief Draftsman in charge of Bridge Division of the Drawing Room, Bethlehem Steel Company; Assistant Engineer of Design with the Port of New York Authority, connected with design of many large structures including the George Washington Bridge, Lincoln Tunnel and others; Chief Structural Designer for the Phelps-Dodge Corporation. Member of Sigma Xi, Tau Beta Pi, American Society of Civil Engineers, American Concrete Institute, Society for Promotion of Engineering Education, Author of "Theory and Practice of Reinforced Concrete," published by McGraw-Hill Book Company in 1939.

James Alvin Johnston, is a graduate of the A. & M. College of Texas, B.S. in Ch.E., 1935; M.S. in Ch.E., Iowa State College, 1936, and Ph.D. in Ch.E., Iowa State College, 1938. Formerly Instructor, Dept. of Petroleum Refining, University of Tulsa. James Gordon Clarke is a graduate of University of Kansas, 1938; B.S. in E.E.; M.Eng., Yale, 1940. James Lathrop Meriam spent three years as undergraduate at the University of California, Los Angeles; transferred to Yale, graduating B.E., 1939. He is now teaching in Engineering Mechanics, Thermodynamics Laboratory and Engineering Drawing. Kenneth W. Lange graduated from Oregon State College 1939, B.S. C.E. He is now taking graduate work in Civil Engineering and also teaching in Engineering Mechanics. Herbert A. Sawyer graduated from Lafayette College 1939, B.S. C.E. He is now taking graduate work in Civil Engineering and also teaching in Engineering Mechanics. Lloyd M. Watson graduated from the University of Saskatchewan 1938, M.S., 1939; was a demonstrator in Chemical Engineering at Saskatchewan and is now teaching in this subject.

In the Electrical Engineering department, Assistant Professors Albert G. Conrad and Francis T. McNamara have been promoted to Associate Professors and Instructor John L. Daley to Assistant Professor.

Charles J. Tilden, Strathcona Professor of Engineering Mechanics since 1918, organizer and Chairman of the Department, has retired. He continues as Chairman of the University's Committee on Transportation.

Within the last year a new Soil Mechanics Laboratory has been installed in the basement of Winchester Hall. It possesses all

equipment necessary for modern soil mechanics instruction and research with the exception, perhaps, of a triaxial compression device which is under construction. Besides purely instructional work, the laboratory does soil investigations for the important structures of the Connecticut State Highway Department and also general research of both practical and theoretical character. Last summer all soil samples for the foundations of the new bridge over the Thames River at New London, Conn., were studied. In this connection not only necessary design data, but also considerable statistical material on the distribution of sand and silt in the cross section of a river under given conditions was obtained. As to general research, the laboratory has proposed to dedicate its activities to two fields, namely, to the study of pressure on tunnels and culverts, and to the study of soil dynamics, as applied to vibrations and nonrigid pavements. Professor Dimitri P. Krynine is in charge of this work.

The College of Engineering of **The State University of Iowa** is offering a three-week Summer Management Course from June 9 to 27, 1941. The course will be under the direction of Professor Ralph M. Barnes.

Although the course is intended primarily for people from industry, several engineering instructors attended last year's course, and we expect a larger number of people from educational institutions this year.

Members of engineering faculties who may be called upon to teach courses in Production Engineering and Production Supervision under the National Defense Training Program for Engineers will find the Summer Management course of value inasmuch as the recommended curriculum for each of these defense courses includes factory planning and motion and time study.

BOOK REVIEWS

Steam Power Stations. GUSTAF A. GAFFERT. McGraw-Hill Book Company; The Maple Press Company, York, Pa. Second edition, 1940. 592 pages.

The author's aim is the production of a dual purpose text, so that an elementary course can be given from the first 17 chapters to acquaint the student with the construction and performance of the separate items of power plant equipment. The final seven chapters are devoted to the application of these items to a complete power plant. They cover the subjects of costs, load curves, plant location, economic selection of equipment, plant cycles (including binary cycles), and station design.

The new edition incorporates a rearrangement of subject matter to make a better division of the material into elementary and advanced work. New problems have been added and new material has been added to cover certain phases of more recent developments. A decided improvement has been made in the discussion of steam generators.

The author has undoubtedly succeeded in improving his text both as to subect matter and arrangement.

Differential and Integral Calculus. ROSS R. MIDDLENUSS. McGraw-Hill Company, 1940. x plus 416 pp. Price $2.50.

One objective in the development of this text in the Calculus has been to simplify and clarify the presentation of theory without loss of rigor or completeness. This objective seems to have been attained, and the text is one which the student should be able to follow easily.

The first chapter presents, in addition to the function concept and notation, instructions for setting up equations and construction of graphs for maximum and minimum problems, and determination of approximate solutions by graph. In view of the average student's difficulty in setting up equations, this practice should be very helpful. Differentiation of implicit and inverse functions is presented early in the text, thus allowing a greater range of problems for applications.

A convenient (and usually necessary) review of the fundamental relations of trigonometry and of logarithms is given before the differentiation of these functions is considered.

The choice of illustrative examples is good; the drawings are excellent. Problems are numerous and varied, and have been chosen to avoid complicated numerical work. They should suffice for the general run of students, but there are few which present any challenge to the superior student.

Kinematics of Machines. GEORGE L. GUILLET. John Wiley & Sons, New York. Fourth Edition. 300 pages. $3.00.

The latest edition brings this book up to date with regard to gear manufacturing standards. Problems have been added to each chapter and there are now 40 drafting room problems instead of the 37 in the former edition.

Changes have been made in portions of the book to make it more clear to the student. The chapter order and titles have been retained. The subjects treated are: General Considerations; Displacement, Velocity, and Acceleration; Instant Centers; Velocity and Acceleration in Plane Motion; Slider-Crank Mechanisms; Cam Mechanisms; Rolling Contact; Toothed Gearing; Gear Trains; Flexible Connectors; and Miscellaneous Mechanisms.

The book is still designed for elementary work with sophomores or juniors.

Elementary Engineering Thermodynamics. VINCENT W. YOUNG AND GILBERT A. YOUNG. McGraw-Hill Book Co., New York. 2nd ed., 1941. 243 pages. $2.75.

In the second edition the authors have retained the original purpose of providing a short but comprehensive text on engineering thermodynamics. The revision includes steam tables and charts based on more recent data by Keenan and Keyes. New and ample lists of problems are given.

A very good feature is the short description of the engineering equipment which precedes the discussion of its theoretical thermodynamic features. Too much can hardly be said about the value of a student's knowledge and interest in the practical application as an incentive to learn the theory.

This book is brief and concise. It would be of value as a text for the theoretical course.

Machine Design. LOUIS J. BRADFORD AND PAUL B. EATON. John Wiley & Sons, New York. 4th ed., 1940. 275 pages. $3.00.

To keep an engineering text that is interesting and of immediate value to the student the authors have discarded obsolete matter and added material and illustrations of the latest practices. The result is a book of about the same length, but with all the material usable and essential.

The revised discussion on gear design, the inclusion of V-belt data, and the material on ball and roller bearings and welded construction all tend to make it more valuable to the student of design.

The many problems included should greatly assist in drill in the fundamentals. This is a comparatively short but inclusive book which covers the field very well.

G. O. MANIFOLD

Technology and Society. S. McKEE ROSEN AND LAURA ROSEN. Macmillan, N. Y., 1940. 465 pp.

Here is a timely little volume. Such a book as this had to come sooner or later to serve the growing number of people who want to know just what effects the increasing number of technological developments are having upon modern society. The two epoch-making reports, (1) *Recent Social Trends,* 1933; and (2) *Technological Trends,* 1937; it is true, supplied the answers to most of these questions. But those *Reports* are too heavy, too detailed, too unwieldly, and too inaccessible for the average reader to use. The Rosens have done an excellent job in digesting those *Reports* and making their tables, charts, and graphs, understandable. Professor W. F. Ogburn's introductory chapter on "National Policy and Technology," in which he includes much of the same material found in his opening chapter in *Technological Trends,* is an excellent approach to this volume. It would not be fair, however, to imply that the authors confined their researches exclusively to the two *Reports* above mentioned. On the contrary, they have drawn upon scores of other recent reports, books, and monographs in assessing the social significance of recent technological developments. And they have described these efforts in a simple style,—one that is easy to read and understand.

In some fifteen chapters ranging from "Manufacture" to "Technology and Human Welfare," the authors discuss the more obvious effects of technology upon society, and venture some interesting speculations of effects that are yet to follow. The half-dozen most important inventions of this century are listed as follows: the telephone, the automobile, the airplane, synthetic chemical products, the radio, and the motion picture. The authors then name what they consider as some of the most important technological triumphs of tomorrow; namely, the development in plastics, synthetic resins (such as bakelite), synthetic rubber, photo-electric cell, the electric ear, television, increased speed and maneuverability of the airplane, and chemical agriculture. Chapters dealing with America's industrial growth, the coming of the automatic machines, the expansion of our communication and transportation systems, and the im-

mediate developments to be expected in these fields, follow in rapid order. Next comes a discussion of the rise of agriculture from Neolithic times to the modern era of Diesel tractors and electricity. In reading Chapter six, one is amazed to discover the extent to which applied science and technology are affecting the various professions. Note the medical professions, to cite only one. Consider the significance of the electrical machines, the electro-cardiograph, the X-ray therapy, radio-therapy, sun ray treatment, the iron lung, and the mechanization involved in the transfusion processes. This is one of the most illuminating chapters in the book. Of equal importance is the discussion relating to the effects of technology upon labor. Of the three types of unemployment, cyclical, seasonal, and technological, the latter is unnecessary, say the authors. New industries could well absorb those workers who are temporarily displaced if only proper attention were given to this problem in advance of the displacement.

This volume is a welcome addition to the growing list of books dealing with our technological civilization. The one shortcoming, so it seems to this reviewer, was the attempt to crowd too many things into one small volume of 465 pages.

JOHN WM. OLIVER

UNIVERSITY OF PITTSBURGH

G-E Campus News

GIANT ATOM SMASHER

SO powerful that its atom-smashing beam of ions would melt an ordinary brick as fast as a blowtorch would melt a pound of butter will be the U. of California's new 100,000,000-volt cyclotron. The 4900-ton giant—16 times more powerful than the present outfit—will generate atomic energies greater than any now in existence except in distant stars or elsewhere in cosmic space.

Atomic particles will be fed into a circular chamber where they will receive successive "kicks," whirling them around in continually widening circles until they reach a window or port on the side of the chamber. The element to be bombarded will be placed over this window where it will receive the full force of the ion beam.

For this machine General Electric is building electric equipment, which will occupy the space of a two-story house. The chief function of this equipment will be to make ordinary electric current capable of operating the giant atom smasher.

DETECTIVE STORY

ALBANY HOSPITAL was in an uproar. The technicians in charge of the hospital's radium supply had lost a radium "needle"—only 3.3 milligrams to be sure, but enough to burn a person seriously if the needle were caught for long in his shoe or clothing.

An appeal for help was sent to the General Electric Research Laboratory in Schenectady for a "Geiger Counter"—an electric "ear" which detects and amplifies the otherwise inaudible "explosion" of the radium as it breaks down.

When Dr. C. W. Hewlett (N. C. State, '06) of the G-E Research Laboratory entered the suspected operating room, the counter immediately began to "cluck" its warning of radioactivity nearby. After a false start, the counter took to the trail like the Hawkshaw it is, and eventually, as Dr. Hewlett lowered it to the floor in front of a radiator, the clucks became barks. And there, snuggled against the wall under the radiator, was the missing radium.

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